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EDN®

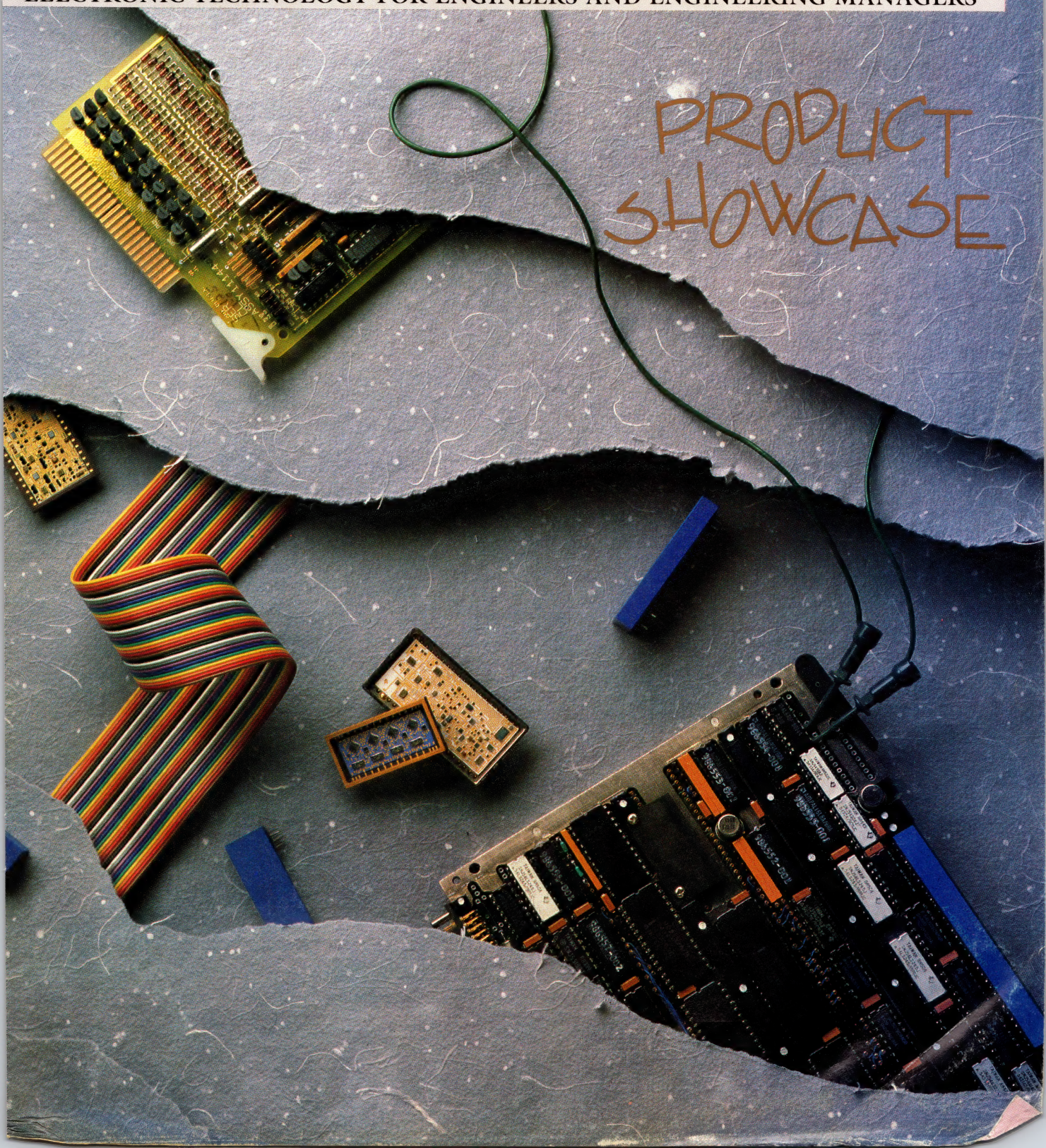
SPECIAL ISSUE—Part 2
Product Showcase No 26

Highlighting key trends in components, instruments, computers & peripherals, and computer-aided engineering

Expanded literature section

4 JAN REC'D

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



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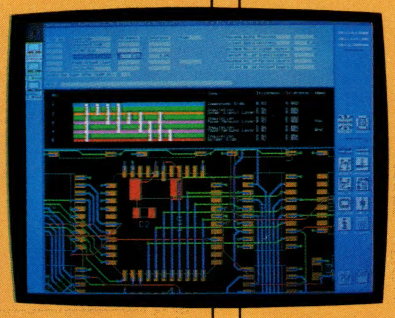

Left: Geometric modeling software enables designers to precisely define surface areas of the most complex products. Right: Newly available AUTOBOARD SMT is designed for the rigors of surface-mount technology. You can design PCBs using blind and buried vias and create them with components on both sides of the boards.

The newest generation of CADDStation systems combine advanced engineering and design capabilities, including production solid modeling, NURBSurface Design,™ finite element modeling and analysis and parametric component libraries. Other features such as 2, 3 and 5 axis machining carry designs forward through manufacturing.

For electronics, CADDStation provides a wide range of fully integrated PCB design software including schematics, simulation analysis, design rule checking, AUTOBOARD® SMT and wiring diagrams.

So if you design, engineer or manufacture a product and want to get it off the ground faster, better and for less, come fly with us.

For more information, call or write: Computervision Corporation, Dept. 425B, 100 Crosby Drive, Bedford, MA 01730, (617) 275-1800.

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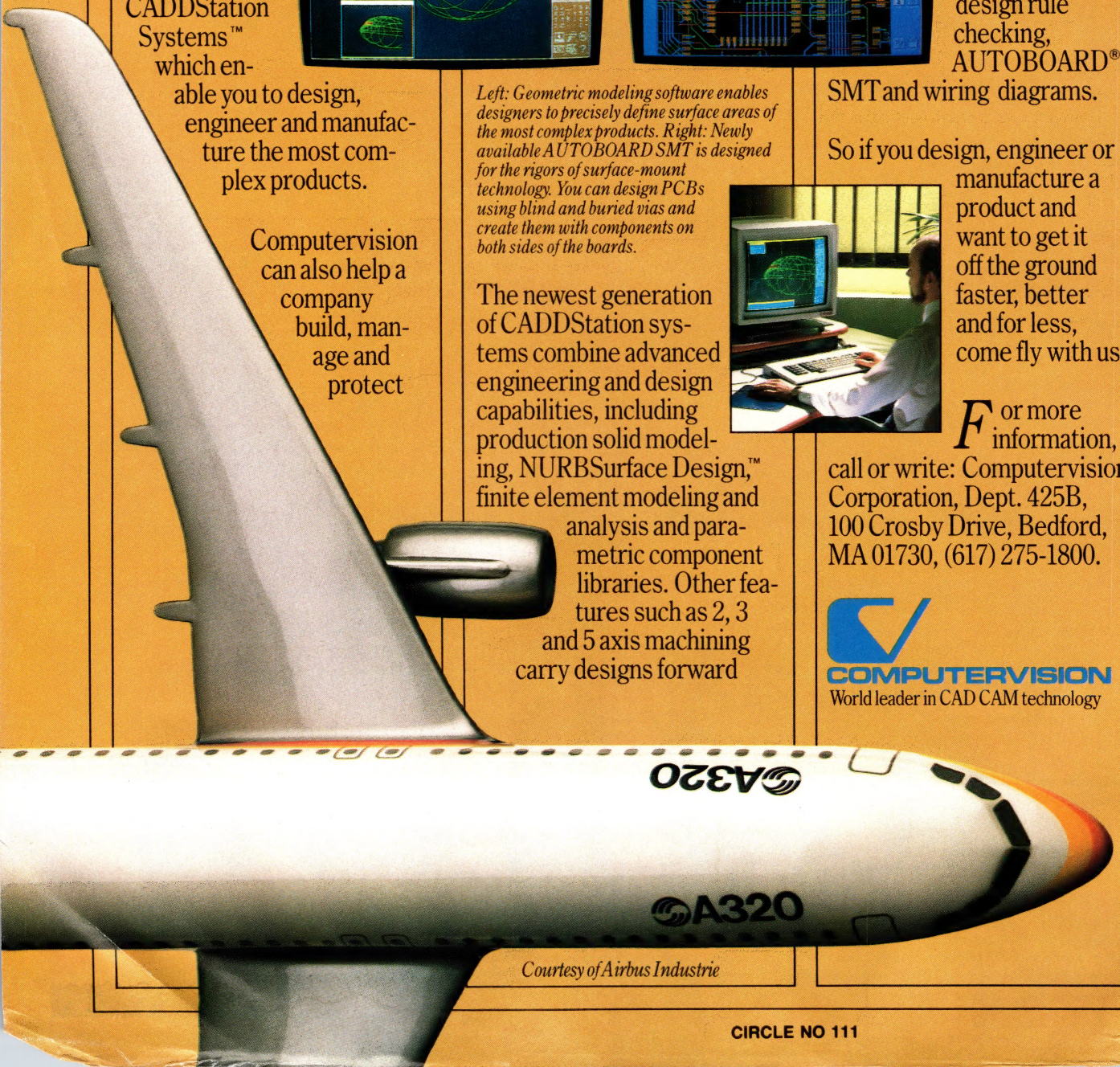
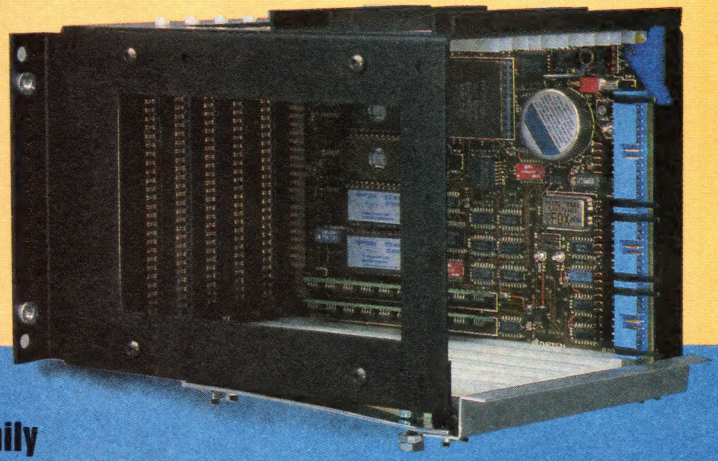


Courtesy of Airbus Industrie

CIRCLE NO 111

From the Company That Wrote the Book on STD DOS...



Ziatech's STD DOS V50 delivers IBM AT performance and software compatibility.

The Industrial Strength Computer Family

STD DOS is Ziatech's implementation of IBM PC DOS on the rugged, low-cost STD Bus, giving industrial control applications access to the huge library of IBM PC software. In other words, a PC tough enough for industrial applications. Ziatech offers a complete family of STD DOS target systems and development tools designed to meet your application's specific requirements.

Single Board IBM AT Performance

The STD DOS V50 system delivers IBM AT performance and software compatibility on a single board STD Bus computer. Its unique surface mount design packages the functionality of many boards into one including: on-board 16-bit data bus, 832K memory capacity, real-time battery-backed clock, AC/DC power-fail protection, interrupt controller, DMA, two serial channels and three counter/timers.

Low Cost DOS, Under $600

STD Mini-DOS runs PC DOS on a single 8088-based STD Bus computer for applications with physical size constraints requiring less than 62K application program memory. Instruments, data-collection terminals, and machine control applications can be equipped for under $600 in single quantities.

The Original STD DOS with More Memory

Ziatech's original two-board set includes an 8088-based single board computer and a DRAM memory board for applications with large memory needs. Both Mini-DOS and the original STD DOS feature two parallel ports, five counter/timers, a serial port, interrupt controller and provisions to add an Intel 8087 math co-processor.

Video Options, New Driver Support, and More

System developers wanting to see more of the STD DOS family can choose from a growing list of options, including an EGA video/keyboard controller, disk subsystems, multiprocessing, solid-state disks, a device driver library called STD DDP, and a soon-to-be-released CMOS STD DOS system.

...Get the Book On STD DOS Free.

Our 24-page STD DOS Technical Brochure shows how our STD DOS systems can begin answering your application's needs. Call or write for a free copy today.

805/541-0488

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ZIATECH CORPORATION

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San Luis Obispo, CA 93401
805/541-0488
ITT Telex: 4992316
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CIRCLE NO 1

PUNCH UP YOUR FLASH A/D PERFORMANCE.

FREEZE VIDEO SIGNALS WITH A SAMPLE & HOLD AMP LIKE THIS.

Introducing the VA730 High-Speed Sample & Hold Amplifier . . . the only monolithic IC of its kind that operates in the 50MHz range.

The only one that's available in surface-mount packaging, and in both commercial and military grades.

And the only one that's designed specifically to operate with 8-bit flash converters.

Best of all, not only is it less costly than expensive hybrids, it's priced well below competing Japanese monolithics.

The VA730 has an A/D converter reference power supply, a sample & hold function, and an ECL clock output section operating to a frequency of 50MHz.

It's available in a 14-pin cerdip package, in a 20-pin ceramic leadless chip carrier (LCC), and in die form.

The VA730 Sample & Hold Amp is just part of VTC's broad line of Linear Signal Processing (LSP) ICs, which includes *Op Amps* to 500MHz gain bandwidth . . . precision, high-speed, and fast settling, plus dual and quad . . . with no sacrifice in performance.

A/D Converters to 12 bits, 1µsec conversion.

Flash Converters to 8 bits, 250MHz.

DACs to 12 bits, 100nsec settling time.

A family of ECL and TTL *High-Speed Comparators* to 1.5GHz.

Video Amps and *Unity Gain Amps* to 2000V/µsec, 300MHz.

And *Operational Transconductance Amplifiers* to 50V/µsec, 75MHz.

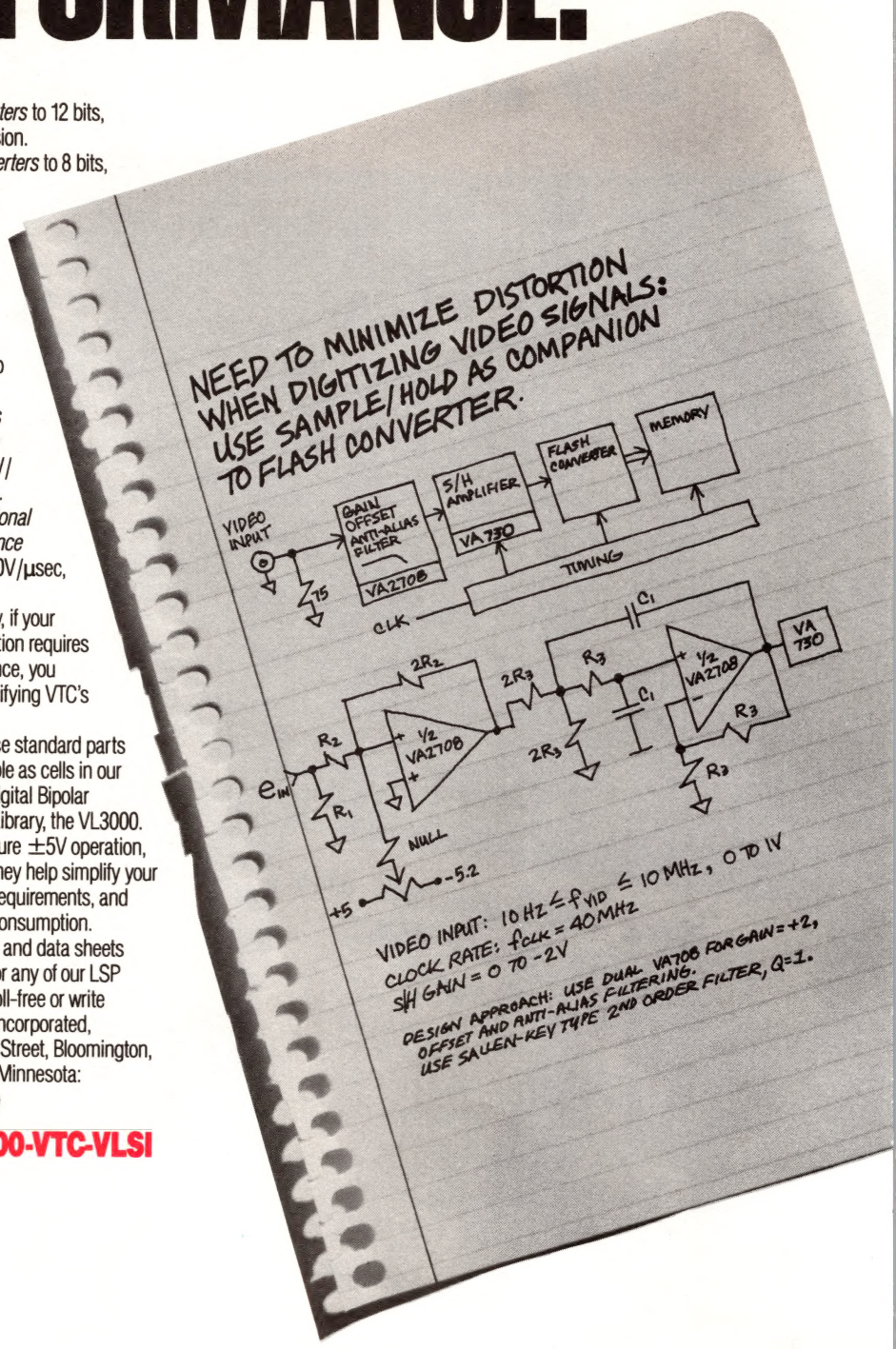
Quite simply, if your analog application requires high performance, you should be specifying VTC's LSP ICs!

Most of these standard parts are also available as cells in our 6GHz Linear/Digital Bipolar Standard Cell Library, the VL3000.

They all feature ±5V operation, which means they help simplify your system power requirements, and reduce power consumption.

For samples and data sheets on the VA730, or any of our LSP products, call toll-free or write us today: VTC Incorporated, 2401 East 86th Street, Bloomington, MN 55420. (In Minnesota: 612/851-5200.)

CALL 1-800-VTC-VLSI



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CIRCLE NO 2

WAVETEK®

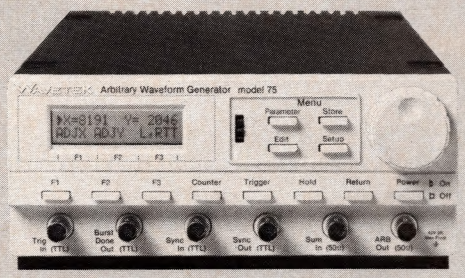
Make any waveform come to life.

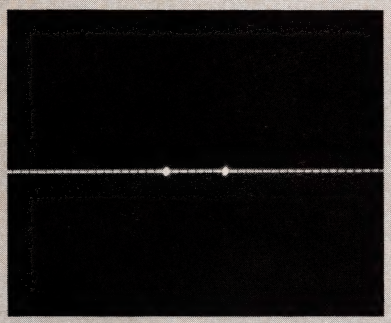
Now you can create arbitrary waveforms in real time just by using your oscilloscope screen. Our new Model 75 Arbitrary Waveform Generator gives you the tools to quickly produce any arbitrary waveshape: insert standard waveform segments, adjust their offset and amplitude, and create non-standard waveforms with our "thumbtack and rubberband" editing system. You can program an entire function visually without ever entering an x/y coordinate.

With more than 4,000 vertical and 8,000 horizontal points available, the most complex waveforms can be created and then stored in Model 75's nonvolatile memory. You can play the waveform back at any rate, then edit it point by point.

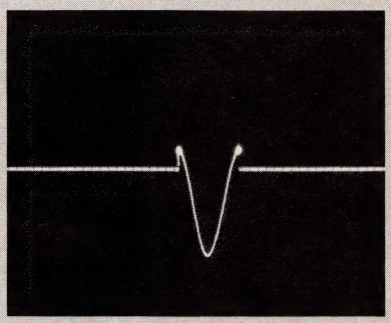
By linking two or more Model 75's together and using their internal counters, sequences of "normal" waveforms can be mixed with bursts of "abnormal" ones, or multiples of a function can be output with phase displacement. An optional IEEE-488 (GPIB) or RS232C interface is also available.

For more information call or write Wavetek San Diego, P.O. Box 85265, 9045 Balboa Ave., San Diego, CA 92138. Phone (619) 279-2200; TWX (910) 335-2007.

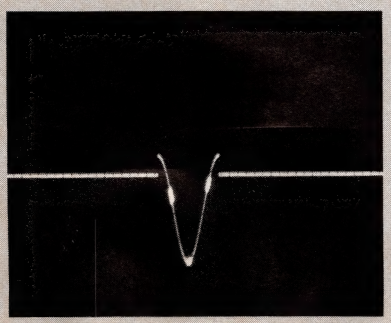




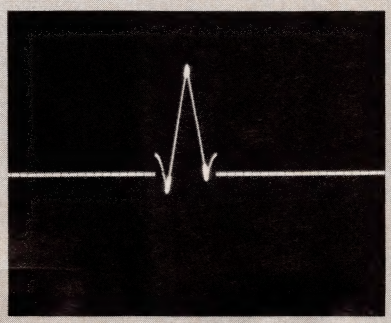
1. Place "thumbtack" markers.



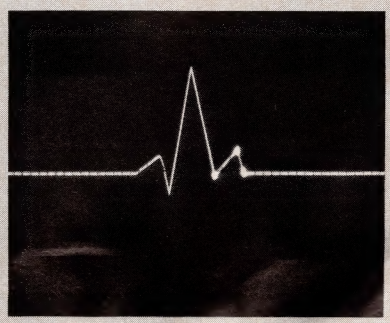
2. Insert standard waveform.



3. Reset "thumbtack" marker positions.



4. Stretch "rubberband" with edit cursor.



5. Move "thumbtacks" and complete waveform editing.

Circle 49 for demonstration

Circle 88 for literature

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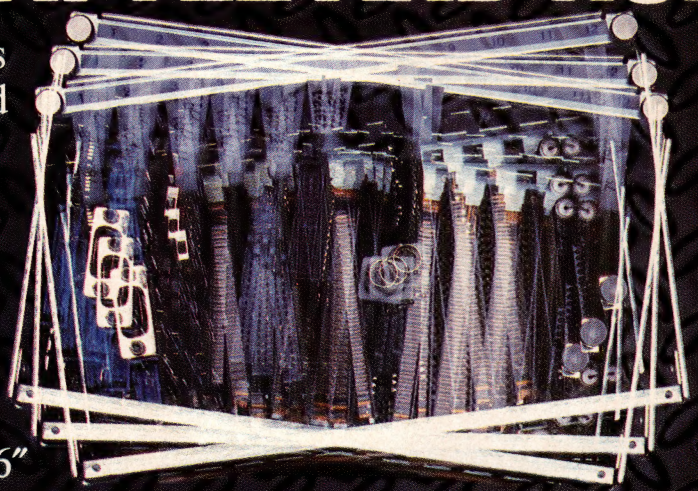
Even while it's working, and it will keep on working for a minimum of 5 years.

System 2 is IBM PC/XT software compatible and fits on a single 4.5″ x 6.6″ card. So, for simple applications, embedding the system is easy, and the cost is minimal.



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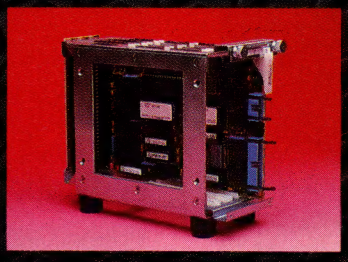
- Shock: Over 20gs
- Reliability: Over 5 year MTBF at 55°C
- Operation: 0 to 65°C
- Parts and labor warranty: 5 years

Specifications

For more complex tasks, memory can be expanded to 640K bytes, EGA and printer interfaces can be added, and semiconductor or bubble memory disk drive options selected. If your environment is not severe, floppy and hard disks are easily added*. If you want to move data on a network, we have Novell or ViaNet compatible ARCNET interfaces.

Whatever your application, you will need I/O and its supporting software. We have up to 23 user slots, a wide selection of digital and analog industrial interfaces and their software drivers. Compatible Plug-in I/O is also supplied by dozens of other manufacturers including Servo and stepper motor controls, bar code readers, voice recognition and response, and GPIB. If you want proprietary I/O, you can design and make your own plug-in boards for System 2.



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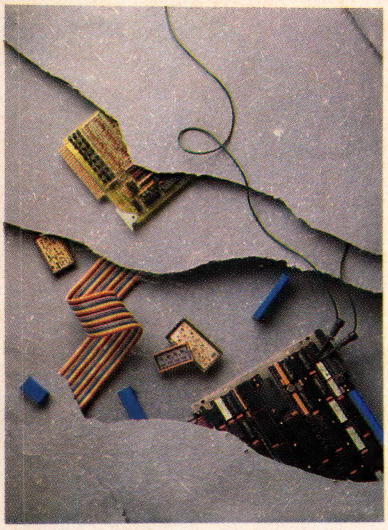
CIRCLE NO 56

Volume 32, Number 26

EDN

December 24, 1987

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Part 2 of EDN's Product Showcase No 26 completes our 1987 coverage of significant new products. This issue begins with a report on logic analyzers (pg 54), which introduces the product section on Instruments. An article on isolation amplifiers (pg 96), represented on the cover by Analog Devices' offerings, leads off the Components section, and a story on HLL cross compilers (pg 126) highlights the Computer-Aided Engineering product section. Complementing the section on Computers and Peripherals is a military-applications computer-systems article (pg 150), which includes boards such as the one on the cover from Titan/SESCO. (Conceptual photography by Dana Sigall; art direction by Kathleen Ruhl)*

DESIGN FEATURES

Instruments

Consider logic analyzers for more than μP applications **54**

Logic analyzers, which are well known to engineers who troubleshoot μP-based systems, can also help you solve hardware and software problems with other digital systems. You'll get the best analyzer for your money if you carefully match the instrument's capabilities with your needs.—*Doug Conner, Regional Editor*

Components

Isolation amplifiers break ground loops and achieve high CMRR **96**

Small size and low cost are creating new applications for today's isolation amplifiers. Based on magnetic, optical, or capacitive techniques, these amplifiers can retrieve microvolt-level signals riding on thousands of volts, can block ground loops, and can reject otherwise catastrophic fault voltages.—*Tarlton Fleming, Associate Editor*

Computer-Aided Engineering

HLL cross compilers speed 1-chip-μC software development **126**

You may be surprised by what today's high-level-language cross compilers have to offer. These advanced software tools can significantly shorten a μC-based product's development cycle, improve code reliability, guarantee programmer portability, and ease software maintenance while imposing minor speed and code-space penalties. —*Steven H Leibson, Regional Editor*

Computers and Peripherals

Low-cost, rugged commercial computers fit military needs **150**

To let your military application take advantage of the wealth of software and support—such as field service and peripherals—that exists for commercial computers, you can use either a MIL-spec or a ruggedized version of a commercial computer system. Which type you choose will depend on a number of cost/performance tradeoffs.—*Margery S Conner, Regional Editor*

1987 Product Database Index **187**

EDN's product database represents products that received editorial coverage in EDN and EDN News between May and October 1987.

Continued on page 7

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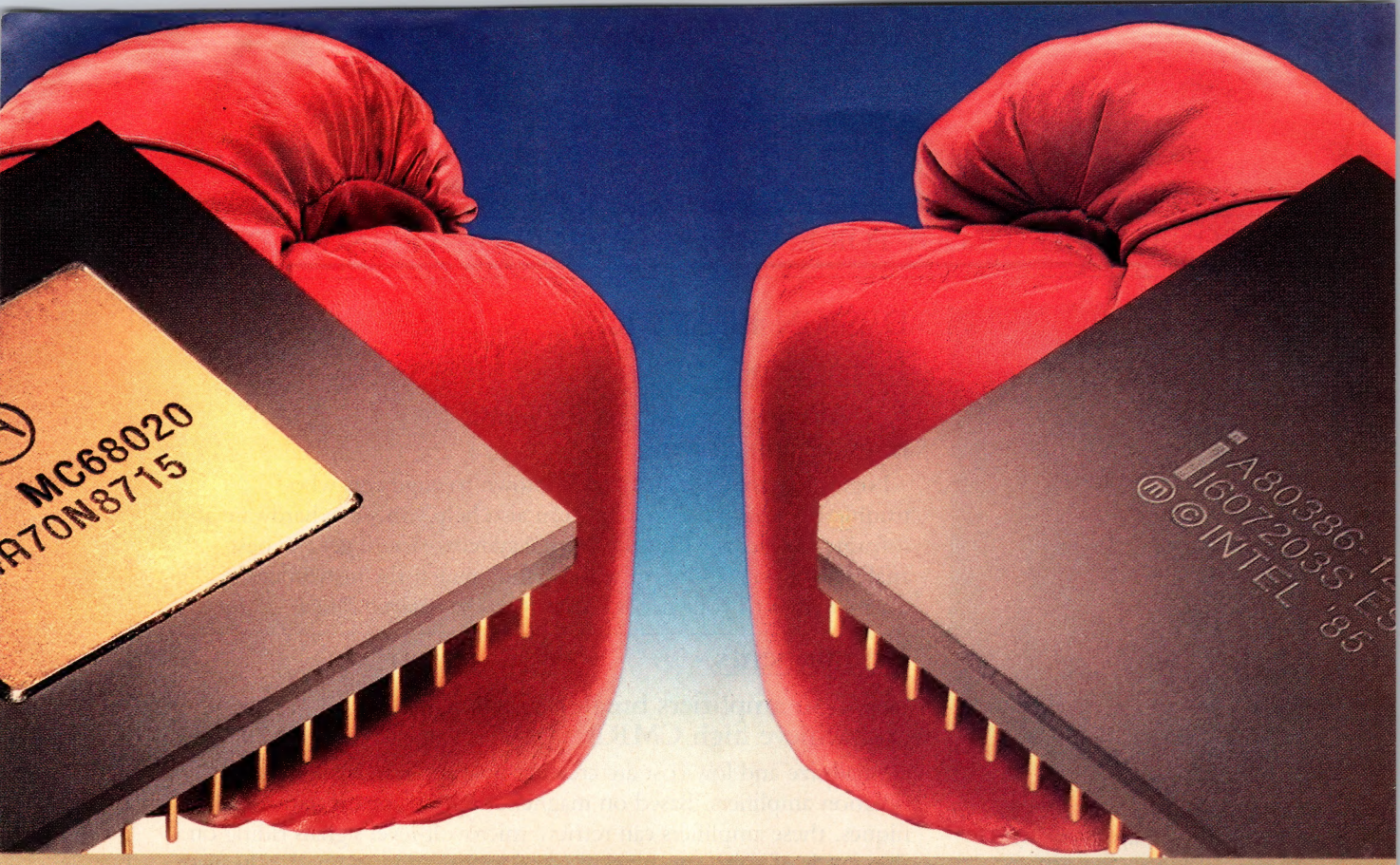

68020 vs. 80386 Who wins? Microtek.

When choosing between the two leading 32-bit processors, don't let emulator support slow you down. Microtek's in-circuit emulators — MICE — offer the highest operations boost available on the market.

Because innovation is no longer a buzz word — but rather, a way of life — your business success relies on your ability to speed up your product-development phase and shorten your design-to-market cycle. Tangible success rests on your ability to get your latest discovery to the marketplace before your competition.

See the promise of such success become reality. Microtek's in-circuit emulators provide the boost in capacity, the hardware breakpoints, the high-level language debugging, and the zero-wait operations that you require to uncover the timesaving efficiency that keeps you ahead of the competition.

And all Microtek emulators use simple command structures and include a symbolic debugger for rapid insight into your real-time behavior.

Furthermore, the MICE family is fully interchangeable — operating as stand-alone or as companion modules for most popular processors and microcontrollers — giving you the ability... and capacity... to take on any challenge, at any time.

Take some of the battle out of business. Rest assured with the knowledge that your product-development pace is as quick as can be, that your design-to-market time is as short as can be.

With MICE on your team, success joins innovation as a way of life.

CIRCLE NO 58

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In the second part of December's Showcase, *you can read about instruments, such as the one shown above, starting on pg 74; components, starting on pg 106; computer-aided engineering, starting on pg 136; and computers and peripherals, starting on pg 162.*

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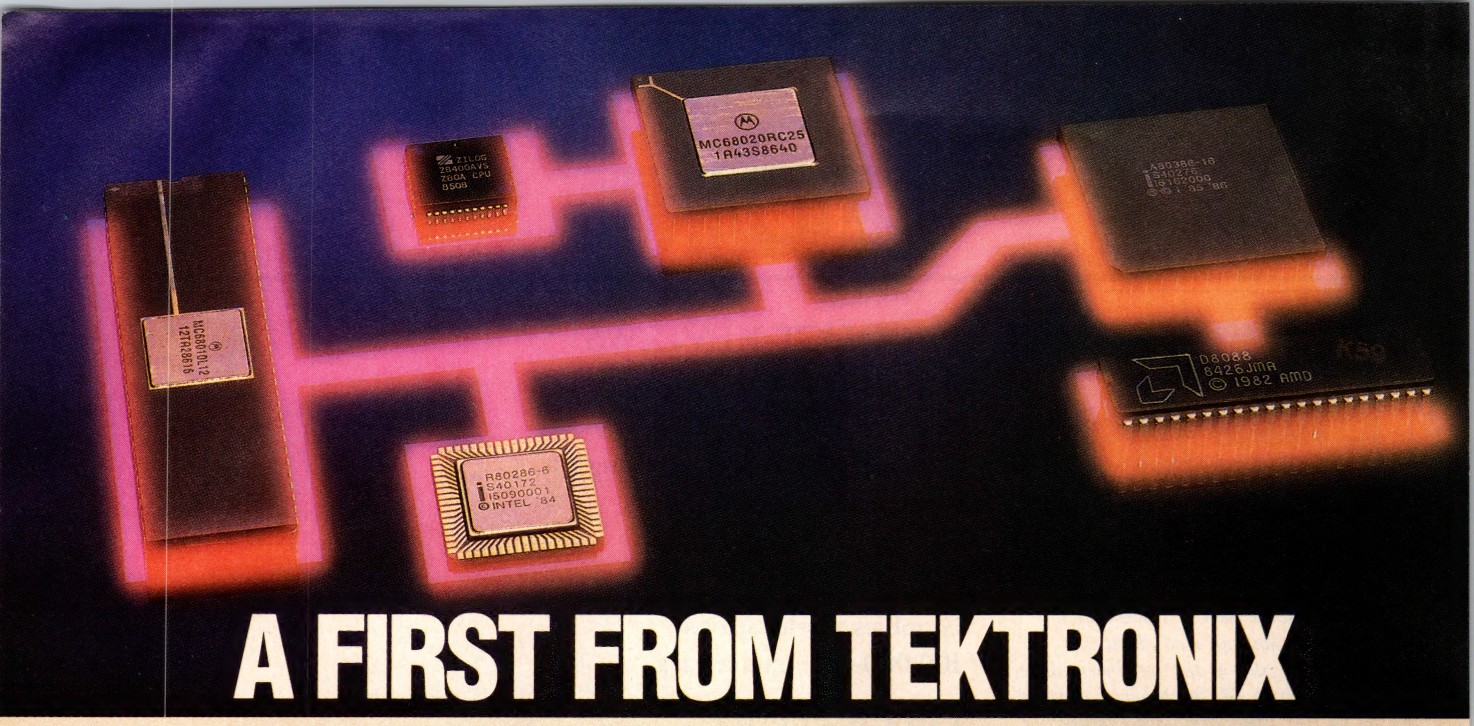


A FIRST FROM TEKTRONIX

HOW TO INTEGRATE UP TO SIX 32-BIT μPs AT ONCE.

Until now, debugging tightly linked multiple micro systems was slow, tedious, hit-and-miss work. Now it's a simple, exact science, using the tools of Tek's DAS9200 Digital Analysis System:

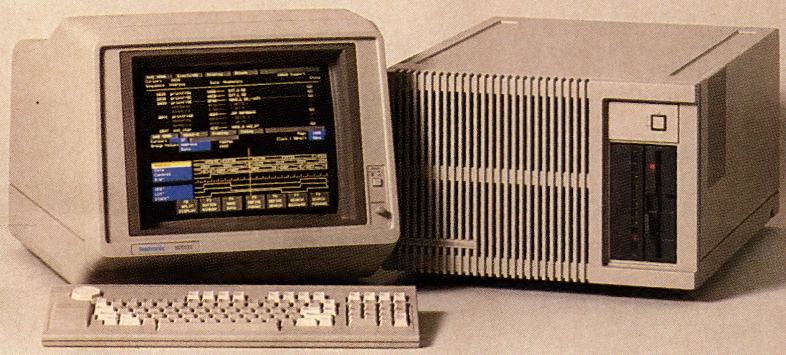
■ **Parallel, independent modules** let you simultaneously acquire 32768 bus transactions from as many as six 8-, 16- or 32-bit microprocessors—including the new, high-end 32-bit μPs. No other system even begins to handle more than *two* at a time.

■ **Time-correlated, split-screen display** lets you scroll through disassembly of time-stamped data acquired from any two microprocessors. You can easily follow what each micro is doing at the same point in time.

■ **Real-time event handshaking** lets one acquisition module arm another—even if running at different speeds.

Or you can link trigger mechanisms on different modules for interactive count and time measurements.

Whatever the combination of hardware and software design segments you need to monitor or integrate, nothing compares with the DAS9200 for pulling them together. For more examples of how the DAS9200 can tackle even the toughest jobs of system analysis, talk to your local Tek representative. Or call: **1-800-245-2036.** In Oregon, 231-1220.



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EDITORIAL 45

Now that 1987 is ending, the time's right to make big plans for 1988.

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How to work with a patent attorney.—*Richard Simonelli, Ziji Technical Services*

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EDN's Design Ideas will return next issue.

A product-oriented design aid

To save you time in your efforts to keep current, EDN's editors have surveyed the new-product offerings from thousands of companies, screening and selecting only the most significant of those offerings introduced in the last six months. We present our findings—the best of the best—in a format designed to make your product selection as easy as possible. You can keep this Product Showcase as a reference until the next one that covers these four key product areas appears in July.

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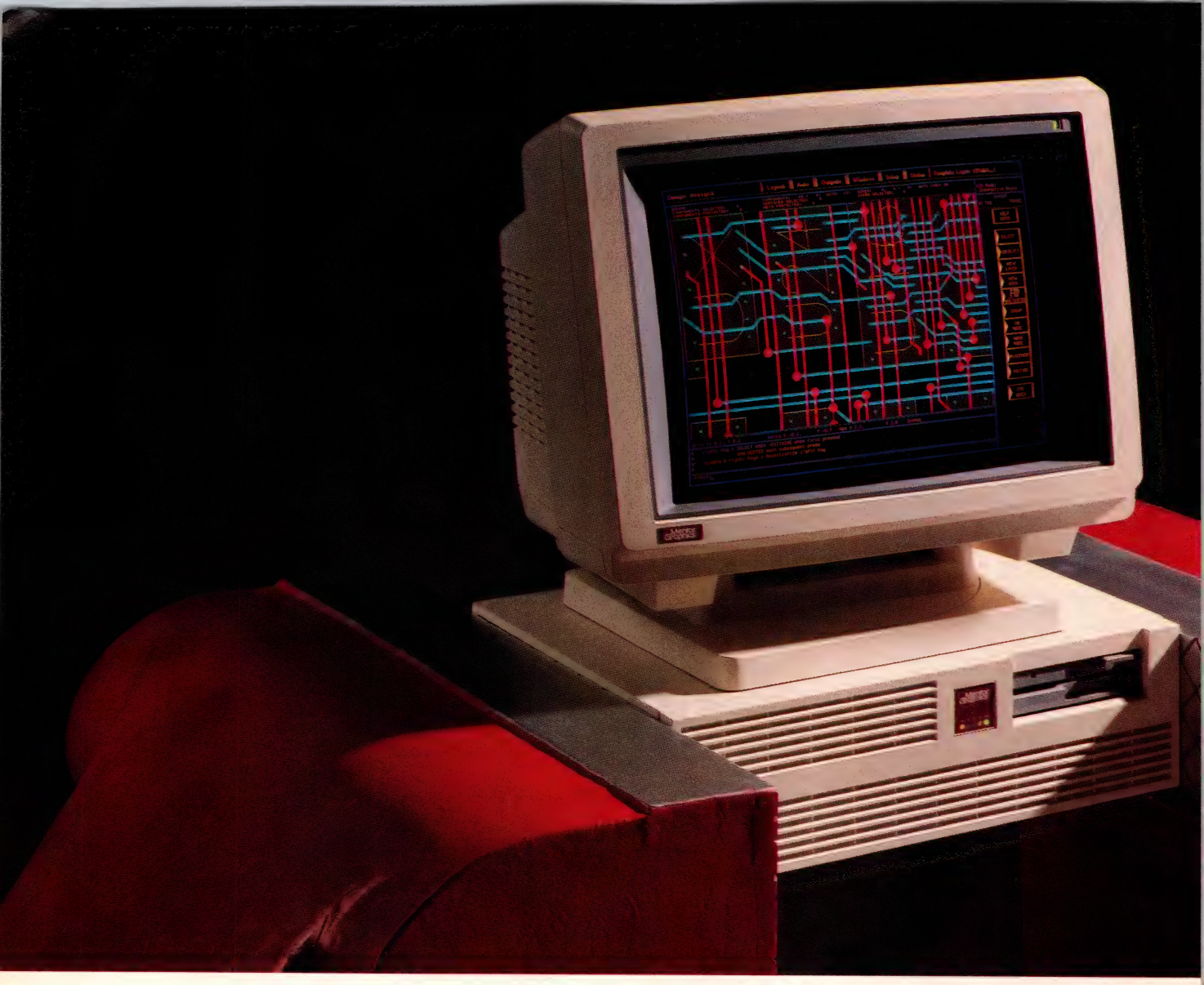

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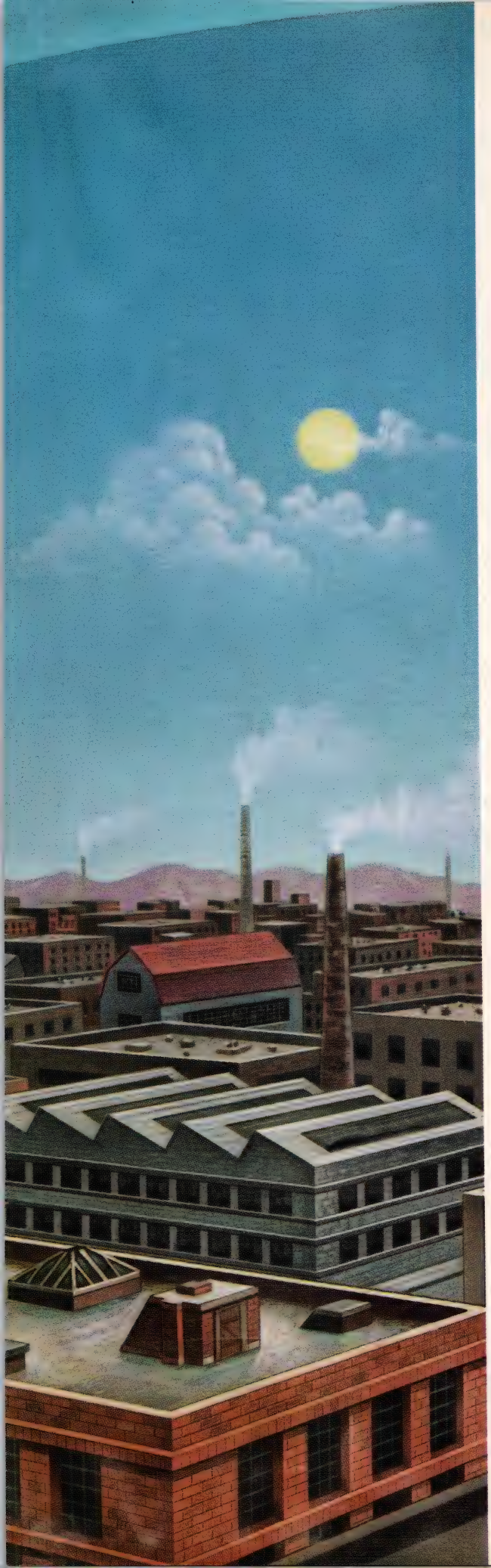

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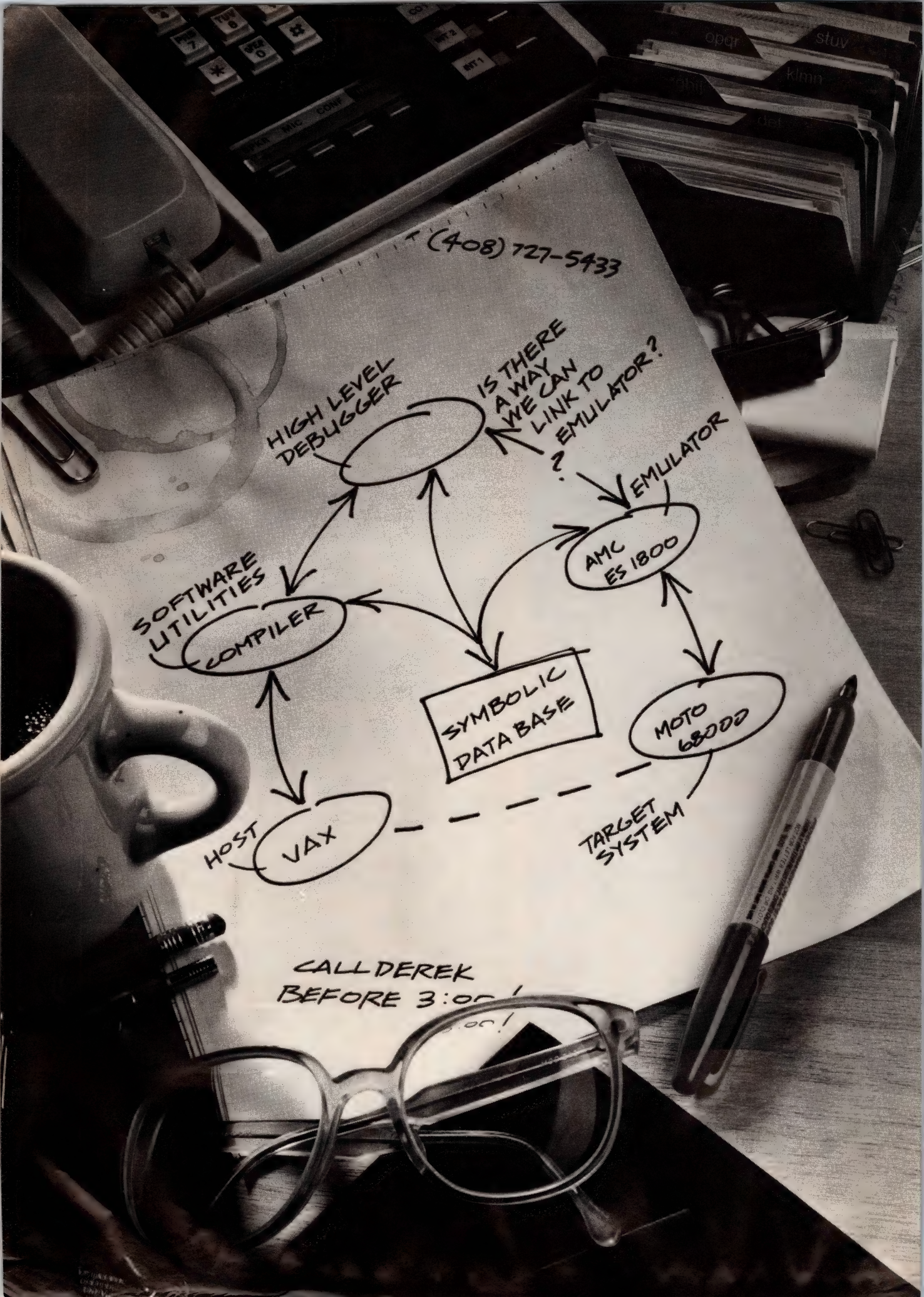
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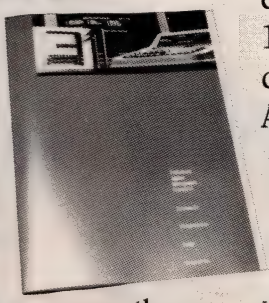

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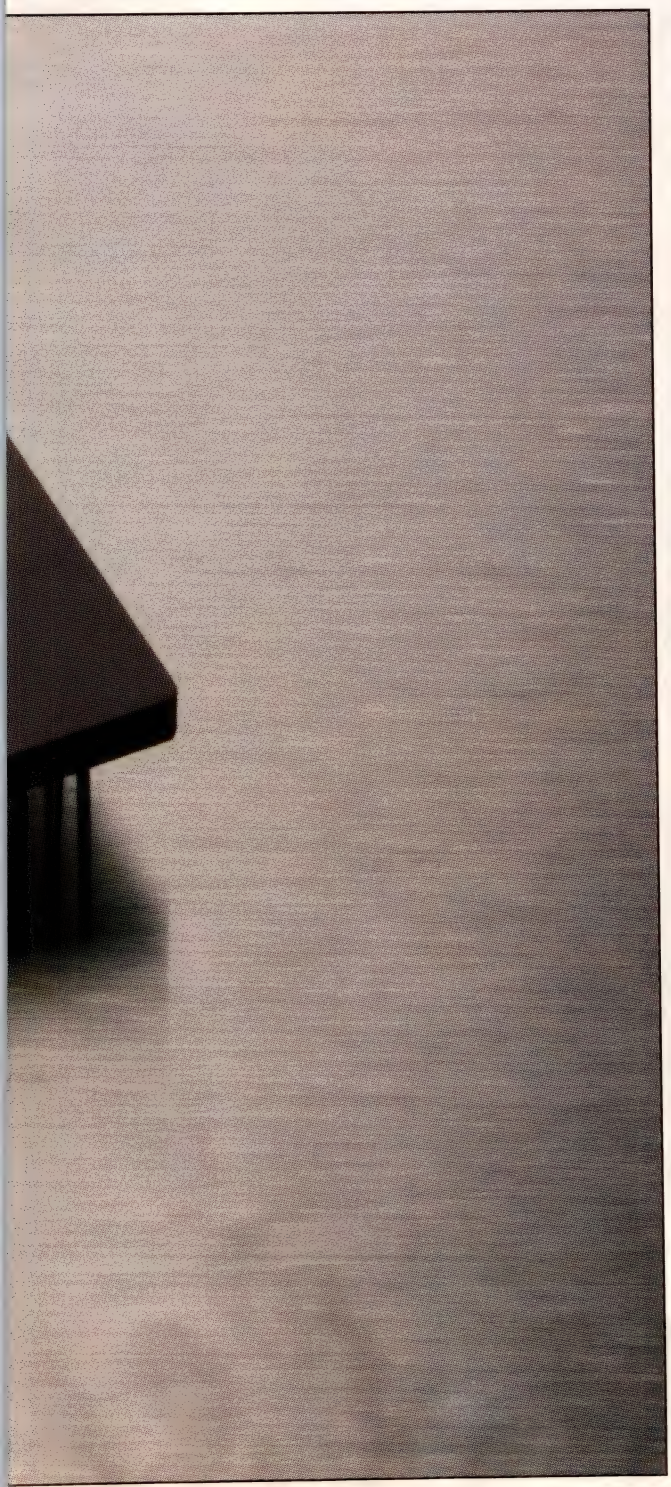

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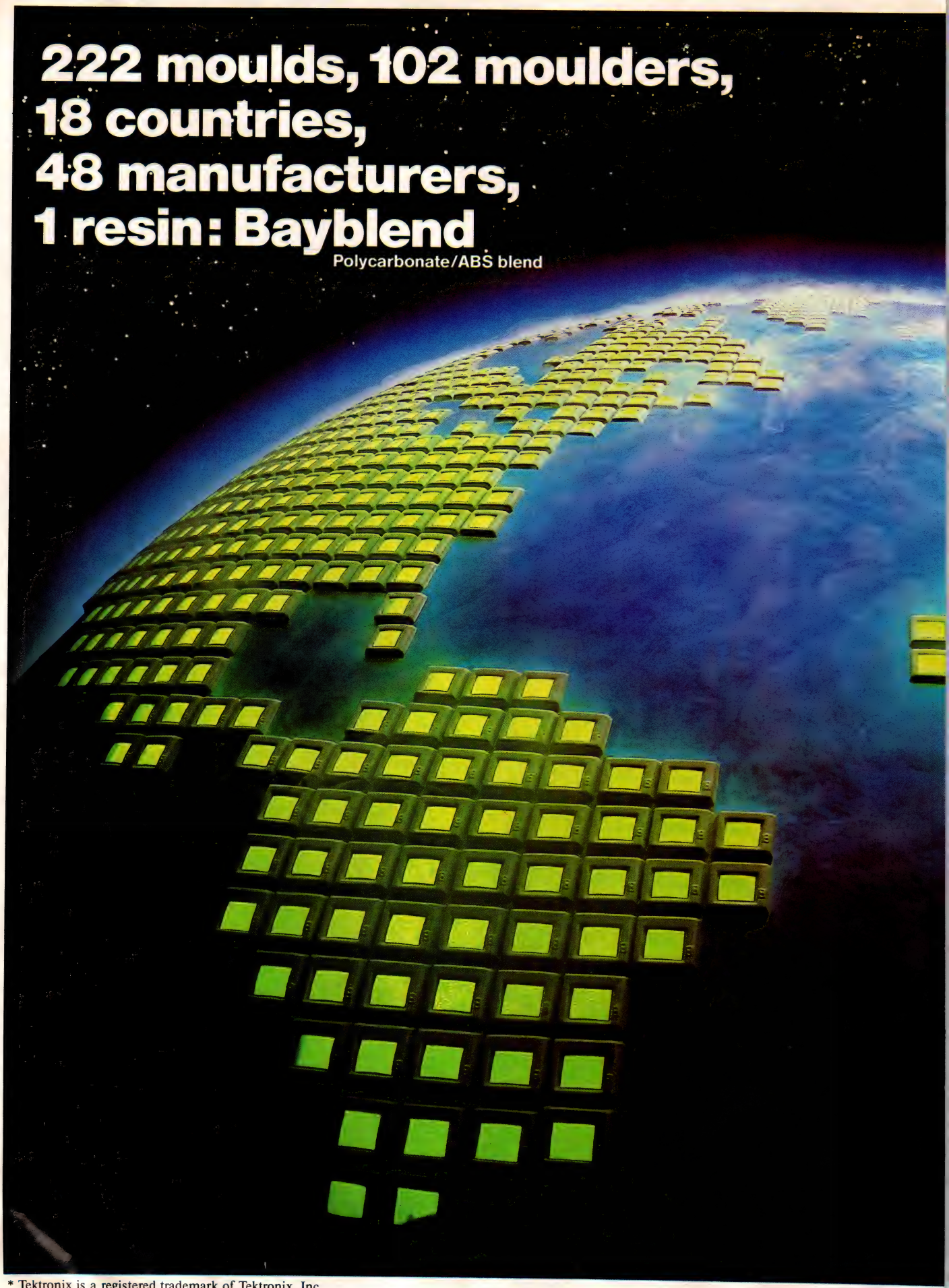

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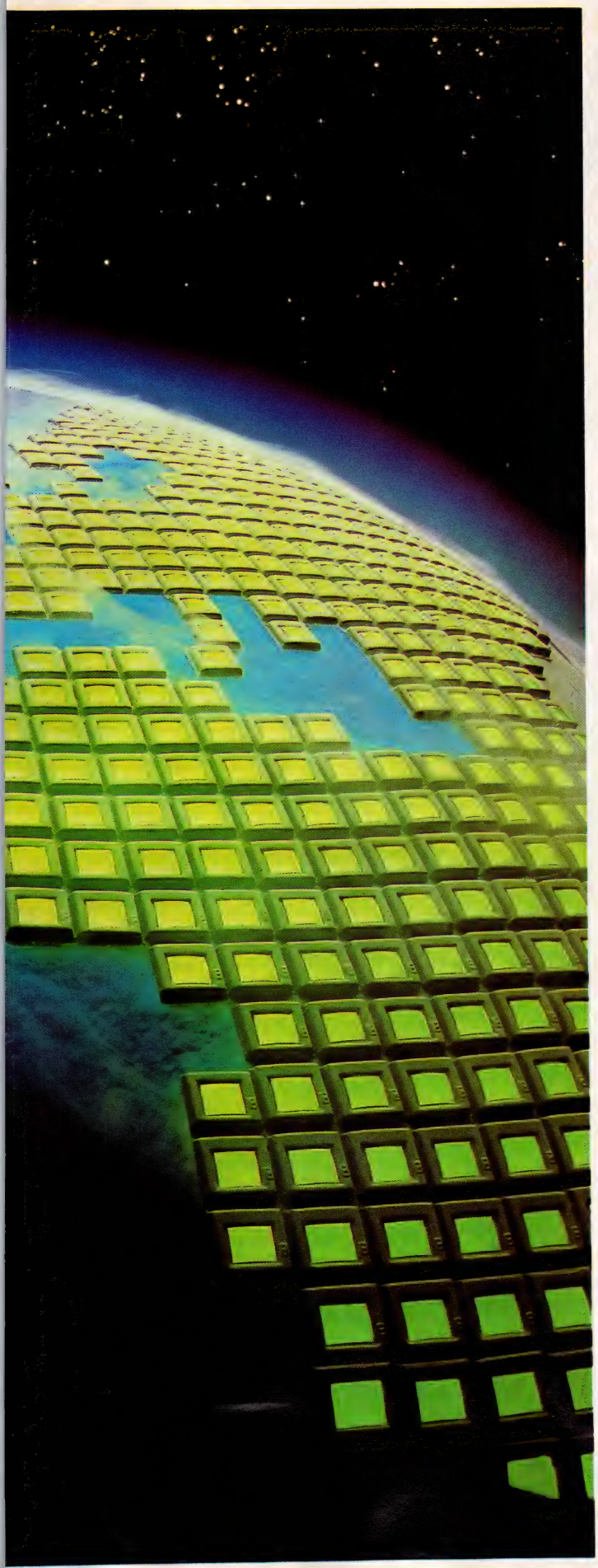

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NEWS BREAKS

EDITED BY JOANNE CLAY AND CHARLES H SMALL

HARDWARE/SOFTWARE ADD-ONS OFFERED FOR SUN WORKSTATIONS

Third-party supplier Artecon Inc (Carlsbad, CA, (619) 931-5500) has introduced a series of hardware and software add-ons for Sun workstations. In the software area, the company offers a menu-driven shell for the Unix operating system. The package, called Artea, presents a consistent user interface across applications ranging from word processing to CAD. It also provides central file management and system administration. A single-user, binary license costs $625, and the company also offers site licenses and quantity discounts.

The company's hardware products expand Sun systems. The desktop modular-storage unit, for example, allows you to add mass storage. The unit includes a cooling fan and power supply and your choice of one or two peripherals (disk or ¼-in. tape). A single-drive disk unit ranges in cost from $4900 to $17,900 for 71M to 636M bytes. The company also offers the VME Pedestal enclosure. The 9-slot VME Bus enclosure replaces Sun enclosures having fewer expansion slots. You can use the VME Pedestal to add data-storage interfaces, memory boards, or other VME Bus cards. You simply remove the boards and peripherals from a Sun system and insert them in the new enclosure. The 9-slot enclosure and power supply costs $5380.—Maury Wright

VOICEBAND ANALOG INTERFACES OFFER LOW-COST DSP CONTROL

Providing a voiceband bandpass/antialiasing filter and a lowpass smoothing filter for speech-compression and -encoding applications, the TCM29C18 and TCM29C19 from Texas Instruments (Dallas, TX, (800) 232-3200) dissipate 60 mW in active mode and 5 mW in standby mode. They cost $3.60 (1000). The difference between the two chips lies in their clock rates: The TCM29C18 requires a 2.048-MHz clock to provide nominal voiceband filtering and 8-kHz sampling; the TCM29C19 requires a 1.536-MHz clock to deliver equivalent performance. Packaged in plastic, 16-pin DIPs, these chips also contain circuitry that performs DSP functions such as signal conditioning, filtering, A/D and D/A conversion, timing, and voltage referencing.—J D Mosley

POP-UP SOFTWARE LETS YOUR PC EMULATE AN HP-41 CALCULATOR

If you never abandoned your yen for reverse-Polish notation, consider using the ELI-41 memory-resident software program from Eclipse Logic (Huntington Park, CA, (213) 569-6020); it lets your IBM PC or compatible computer operate as a Hewlett-Packard 41 Series scientific calculator. This $99.95 package lets you run HP-41 programs and perform calculations to 15 digits of precision. The company even offers all of the HP-41 engineering, control, math, and statistics libraries on DOS-compatible floppy disks. Because the program is memory resident, you can access ELI-41 while running another application program.—J D Mosley

CAD/CAE SOFTWARE AIDS IN MICROWAVE HYBRID AND CHIP DESIGN

Hewlett-Packard's (Palo Alto, CA) HP 85150A microwave-design system helps you to design hybrid and monolithic microwave circuits by providing software for schematic capture, simulation, and artwork generation. The $29,000 package runs on the company's HP 9000 Series 300 workstations. After you enter the schematic, the simulator uses frequency-domain, linear simulation to check the circuit. The company refined the 85150A's software-simulation models to reflect data obtained from real devices with its HP 8510 microwave network analyzer. An artwork generator automatically converts your schematic to hybrid layouts or monolithic-IC designs, and a graphics editor allows you to refine those automatically generated designs. Deliveries of the design system will begin in May 1988.—Steven H Leibson

NEWS BREAKS

3-GHz GaAs LASER DRIVER SUITS FIBER-OPTICS APPLICATIONS

Complementing its transimpedance amplifier, wideband amplifiers, and high-speed comparator, Anadigics Inc's (Warren, NJ, (201) 668-5000) latest circuit for fiber-optic applications is a 3-GHz GaAs laser driver. The ALD30010 operates over the frequency range of 10 kHz to 3 GHz and represents another step in the company's quest to provide a GaAs chip set for the transmitter and receiver sections of high-data-rate fiber-optic systems. Because of an on-chip phase splitter that also provides gain, the ALD30010 needs only a 0.6V p-p (0 dBm), single-ended input signal, and it can supply 35 mA of modulation current to the laser diode.

The ALD30010 can operate to 4.5 GHz as an analog current driver and to 5G bps in digital fiber-optic systems. You can also use the device as a wideband buffer amplifier that features voltage-controlled gain and offset functions. The ALD30010 costs $43.50 (1000) in chip form and $65 in an 8-pin flat pack.—Dave Pryce

SELF-CALIBRATING 13-BIT ADC INCLUDES S/H CONVERTER

Featuring the first successive-approximation algorithm of its type ever to be implemented on a monolithic chip, the ML2230 A/D converter from Micro Linear Corp (San Jose, CA, (408) 262-5200) can produce a 12-bit-plus-sign sample every 30 μsec. You can connect the device directly (without adding TTL gates) to μPs such as the 80C51 and the 80C186; the 68000 μP family requires only a 74LS00 package to separate the RD and WR lines. On command, the converter performs a 2-msec self-calibration: After nulling the loop offsets, the circuit adjusts its loop gain to a precise value of two.

The ML2230 requires less area than a conventional S-A type does, because its conversion algorithm doesn't use a D/A converter for feeding back the successive-approximation trial values. Self-calibration and the absence of a D/A converter thus eliminate any need for component trimming during the ML2230's manufacture. Built-in diagnostics provide self-tests for the analog and digital circuitry, as well as a debugging aid during your system-design cycle. Suitable for 8-bit data buses, the ML2230 comes in a 24-pin DIP; a version with ±½-LSB linearity costs $25.95 (100). For the same price you can order the ML2233, a similar product that features 13 output lines for direct interface to a 16-bit data bus.—Tarlton Fleming

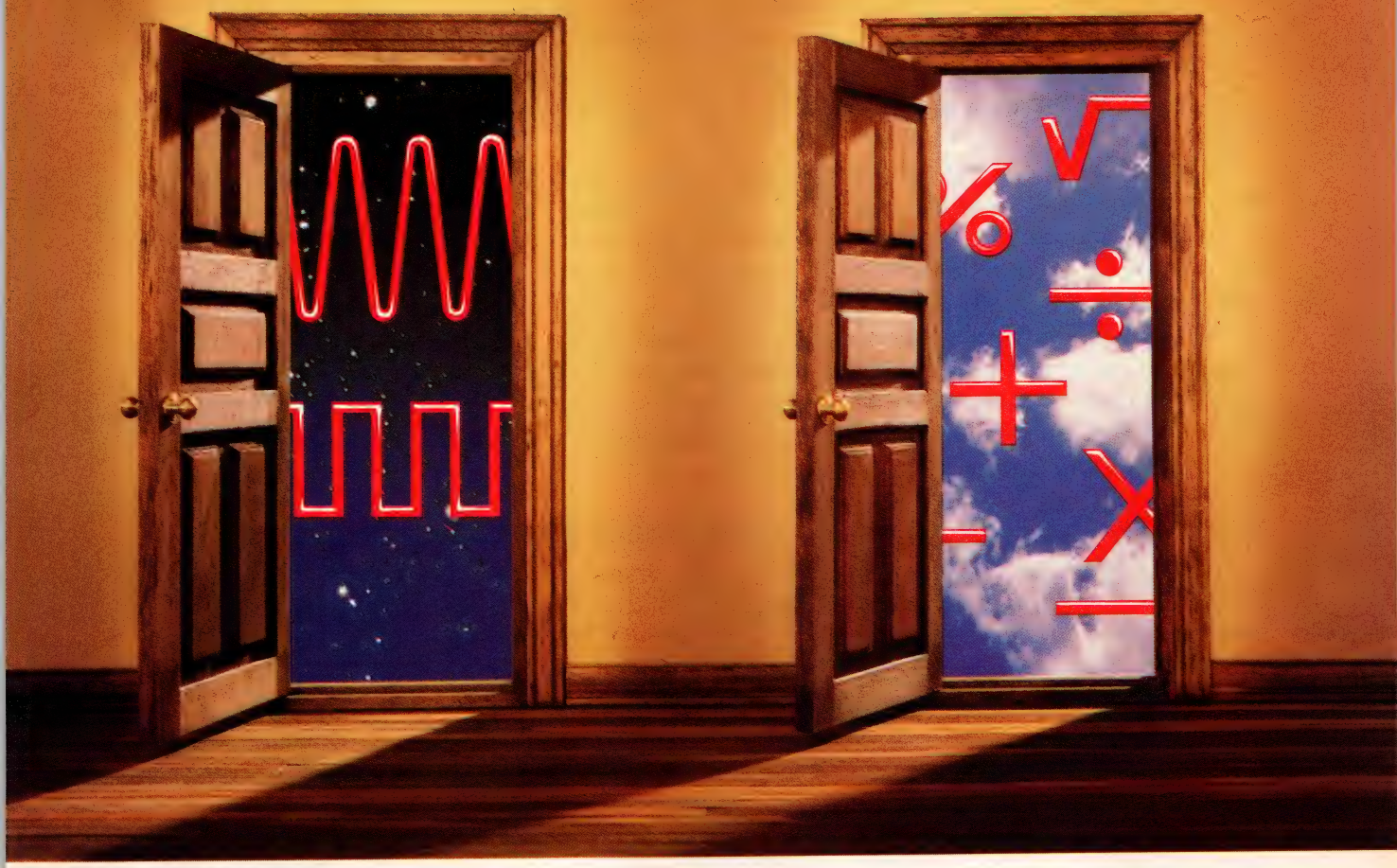
OPTICAL MEDIA HAVE 30-YEAR WARRANTY

To counter concerns about optical-media life, Laser Magnetic Storage International Co (Colorado Springs, CO, (303) 593-7900) now provides a written, 30-year warranty on its 12-in. write-once, read-many (WORM) Laserdrive disks. Based on accelerated life testing, the warranty covers materials and defects on the unwritten media and also guarantees that the media will be readable for 30 years. Should you have a data-recovery problem on the media, the company will assist you in retrieving the data and will replace the bad disk at no charge.—Steven H Leibson

ANALOG SILICON COMPILER LETS YOU DESIGN 20TH-ORDER FILTERS

The SCF Compiler from International Microelectronic Products (IMP) Corp (San Jose, CA, (408) 432-9100) is an analog silicon compiler for the synthesis, simulation, analysis, and physical design of switched-capacitor-filter circuits on the company's CMOS, combined analog-digital ASICs. The specification portion of the package is free to IMP customers; it supports the implementation of Butterworth, Chebyshev, and elliptic filters of as great as 20th-order complexity.—Jim Wiegand

Bringing the Worlds of Data Acquisition and DSP Together



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NEWS BREAKS: INTERNATIONAL

PARALLEL-PROCESSING UNIX COMPUTER ACHIEVES 80 MIPS

Integrated Micro Products (Consett, UK, TLX 537747) is developing a VME/VSB Bus parallel-processing, multiuser Unix computer that is capable of 80-MIPS operation. The computer occupies a 21-slot VME Bus backplane populated with a number of cards: CPU cards that accommodate multiple 68030 μPs; multiple-card memory subsystems that provide as much as 256M bytes of RAM; an intelligent, caching disk-controller card; and 16-channel serial I/O cards. The computer can accommodate more than 200 users.

A Uniplus+ operating-system kernel—written specially for the development project by Root Computers Ltd (London, UK, TLX 885995)—dynamically allocates users' tasks among the system's processors. Despite its ability to run tasks in a parallel-processing environment, the kernel offers the same operating-system calls as does a single-processor Uniplus+ system. Therefore, the computer maintains true binary compatibility with software that runs on single-processor Uniplus+ computers. The project, code-named Magix, is under development with a port of Uniplus+ version 2.2. However, the company intends to supply the computer—probably around the middle of 1988—with Uniplus+ version 3. The fully loaded computer will probably sell for less than £100,000.—Peter Harold

STEPPER-MOTOR DRIVERS EASE INTERFACE TO SINGLE-CHIP μP

Mietec (Oudenaarde, Belgium, TLX 85739) plans to introduce two stepper-motor driver ICs during the first half of 1988. The MTC6017 is an H-bridge driver that's suitable for controlling the current in one winding of a bipolar stepper motor. Its pinout, its drive capability (0.8A continuous), and its basic functions are similar to those of the industry-standard 3717-type driver. However, the MTC6017 sports two pins that a single-chip μP can use to program the winding current's level. Further, the device includes an on-chip 5V reference for its current-sense comparator. Another device with similar maximum drive current, the MTC6018, targets microstepping applications. It will provide a 6-bit on-chip D/A converter for winding-current control. The MTC6017 and MTC6018 will cost approximately $2.20 and $2.50, respectively.—Peter Harold

ALTERNATE SOURCE AVAILABLE FOR 1-CHIP μCs

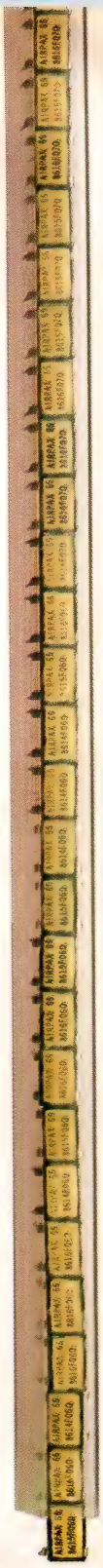
NEC has agreed in principle to allow Matra Harris (Nantes, France) to act as an alternate source for NEC's μPD78312 and 78310 single-chip microcomputers. The two devices are proprietary μCs that NEC targets at industrial-control and computer-product applications. This agreement marks the first time that NEC has licensed a foreign company to act as an alternate source.—Tom Ormond

DEVELOPING ASIAN NATIONS TO BUY 8% OF SEMICONDUCTORS IN 1988

South Korea, Taiwan, Hong Kong, and Singapore are expected to consume about 8% —or approximately $2.9 billion—of the world's semiconductor production in 1988, according to the Electronics Industries Association of Japan (EIAJ). This figure represents an increase of 18% over the countries' 1987 consumption. The South Korean market will show the greatest growth; it's expected to demand $950 million worth of semiconductors in the coming year. EIAJ predicts that Taiwan will run a close second, purchasing $910 million worth of the world's semiconductors in 1988.—Joanne Clay

FINALLY, A SNAP-ACTION THERMOSTAT IN A DIP PACKAGE.

New Airpax Series 6600 thermostats are specially designed to be compatible with all automated production techniques common to PC board manufacturing. They can be installed with DIP auto-insertion equipment. They are sealed to withstand wave soldering and washing operations. And they provide both sensing and switching in a single space-saving device. Best of all, the Series 6600 combines production expediency with proven accuracy and reliability. Bimetallic snap-acting thermostats, the Series 6600 feature fast, positive response and excellent repeatability with 1 amp switching capability over a temperature range of 40°C (104°F) to 120°C (248°F). To ensure performance, the temperature is factory pre-set, and cannot be altered in the field. Add automated thermostat installation to your PC board production line. Call us today for configuration availability and further details. Airpax Corporation, Frederick Division, Husky Park, Frederick, MD 21701. (301) 663-5141. A North American Philips Company.



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Center Frequency (MHz)	30	42	50	60	70
Bandpass (MHz) 1dB max.	25-35	35-49	41-58	50-70	58-82
Stopband (Mhz) 10dB min.	7-120	10-168	12-200	14-240	16-280
Stopband (Mhz) 20dB min.	2-210	3-300	3-350	4-400	5-490

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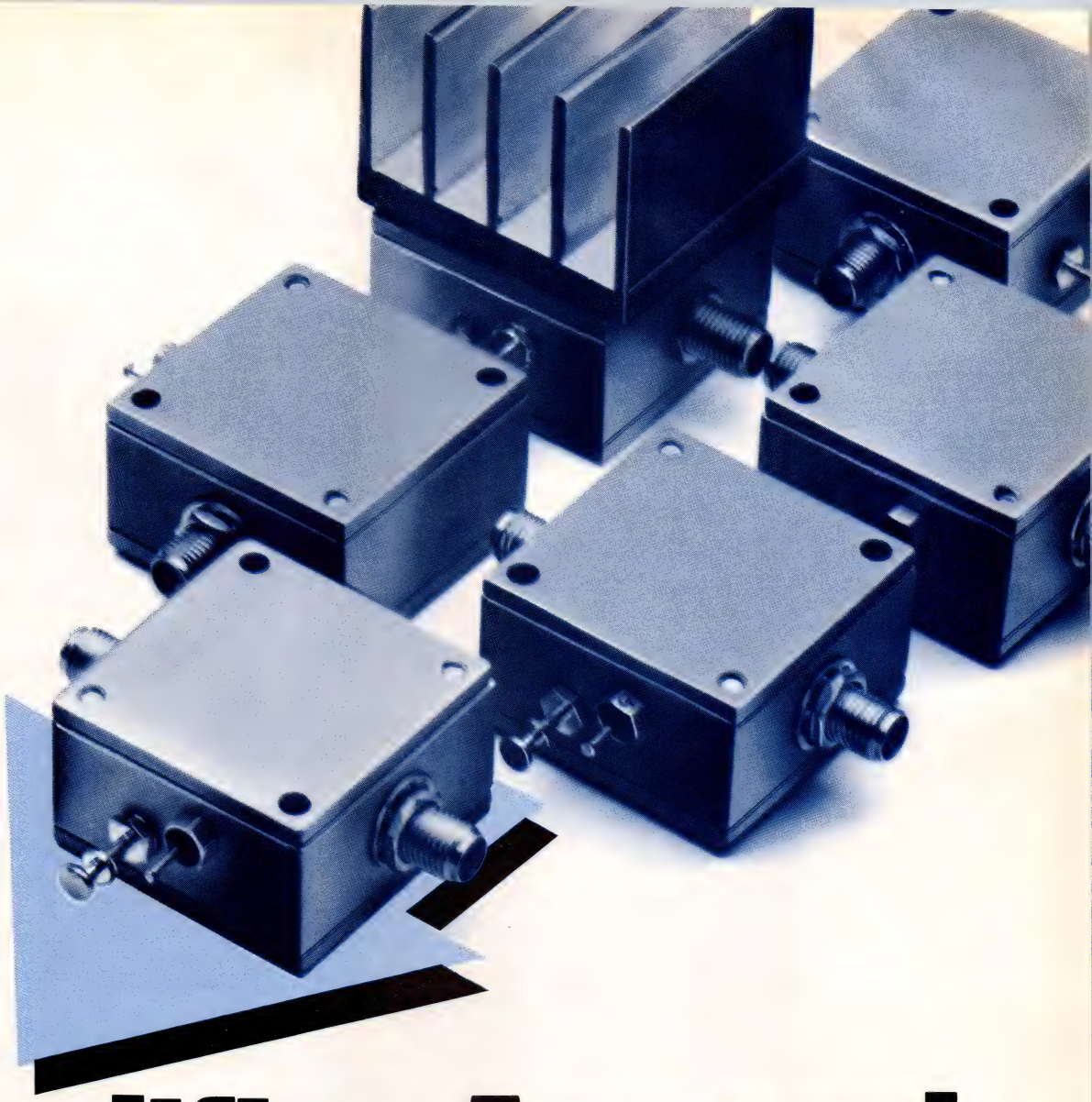
CIRCLE NO 65

C119 REV. ORIG.



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Need more output? Our ZFL-1000H, flat from 10 to 1000MHz, delivers +20dBm output.

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Variable gain important? Our ZFL-1000G, flat from 10 to 1000MHz, delivers +3dBm output with 30dB gain control while maintaining constant input/output impedance.

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One week delivery...one year guarantee.

SPECIFICATIONS

MODEL	FREQUENCY MHz	GAIN, dB (min.)	MAX. POWER OUTPUT dBm(typ)	NF dB(typ)	PRICE $ Ea.	Qty.
ZFL-500	0.05-500	20	+9	5.3	69.95	1-24
ZFL-500LN	0.1-500	24	+5	2.9	79.95	1-24
ZFL-750	0.2-750	18	+9	6.0	74.95	1-24
ZFL-1000	0.1-1000	17	+9	6.0	79.95	1-24
ZFL-1000G*	10-1000	17	+3	12.0	199.00	1-9
ZFL-1000H	10-1000	28	+20	5.0	219.00	1-9
ZFL-1000LN	0.1-1000	20	+3	2.9	89.95	1-24
ZFL-2000	10-2000	20	+17**	7.0	219.00	1-9

* 30dB gain control **+15dBm below 1000MHz

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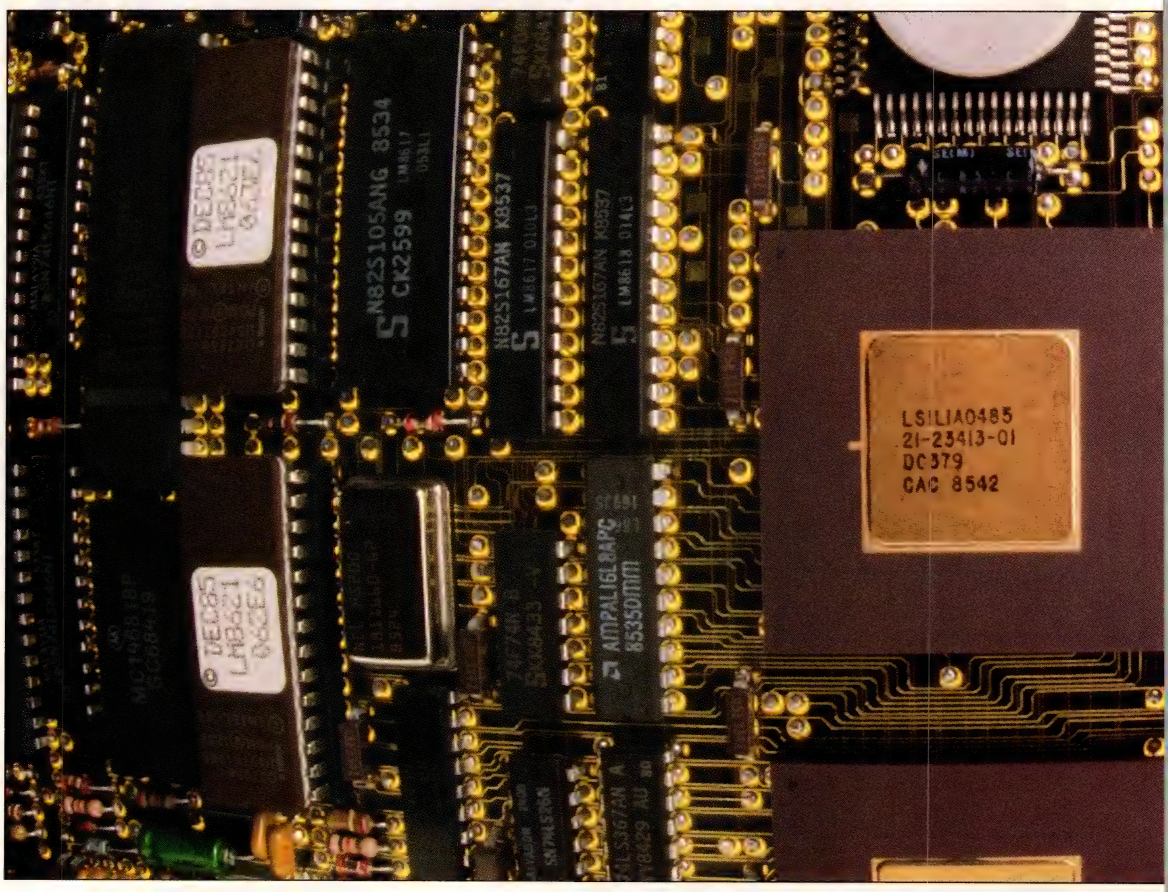
C101 REV.C

CIRCLE NO 66

If you're not finding Gate Array, Advanced Schottky, and SMT faults, maybe the fault lies with your tester.

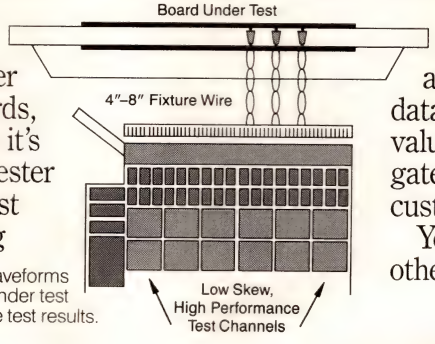


Introducing Teradyne's L210i. The only true VLSI in-circuit tester.

There are a lot of other in-circuit testers out there. But on VLSI boards, all they test is your patience.

Now there's the L210i VLSI In-Circuit Tester from Teradyne. It has over 3,000 bidirectional test pins. With digital, analog, and memory testing on every pin. And 10 MHz pattern rates.

Most importantly, the L210i delivers 95% or greater fault coverage on VLSI boards, in just 1–2 months. Because it's the first and only in-circuit tester that handles the three biggest problems in in-circuit testing today.



The L210i delivers waveforms accurately at the board under test for repeatable test results.

Test ASIC's ASAP.

One of the biggest problems for in-circuit testers today is ASIC's. If they detect ASIC faults at all, it's only because you've spent weeks and weeks programming them.

Not so with the L210i. It has a unique VLSI device tester architecture. So you can use patterns from device design and test databases. The L210i's translators convert patterns quickly.

Plus, the L210i stores and processes lengthy test data efficiently. So you save valuable time in testing gate arrays and other semi-custom devices.

You won't find that in any other in-circuit tester.

Repeatability. Repeatability. Repeatability.

With the L210i, you won't be plagued by unreliable tests of your high performance logic. False clocking. Or shifting signal timing.

Because the L210i features short, low inductance fixture wiring. Superb driver electronics. And powerful debug tools. So everything you test gets tested repeatedly. Including high speed ECL and FAST.* Even Advanced Schottky and CMOS, with their tricky overdrive impedances.

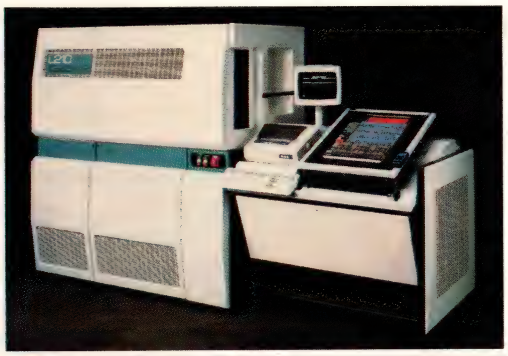
The L210i fears no logic.

The only in-circuit tester with an escape hatch.

The L210i is the only in-circuit tester that's flexible enough to test today's SMT clusters. Memory arrays. Or hard-to-isolate devices.

With its MultiMode capability, you can easily partition the board into functional clusters, making the most of the L210i's functional test and diagnostic techniques.

That means you'll never be trapped by in-circuit testability problems again.



The L210i is Teradyne's first board tester for VLSI in-circuit testing, and in-circuit tester budgets.

No-fault insurance.

Teradyne's L200 family has set the standard for VLSI board testing in this decade, driving test quality up to bring costs down.

Now the L210i offers the first practical VLSI in-circuit test solution. It's the system you need to boost board yields at system test. And make your in-circuit test strategy successful.

If you can't afford a tester that misses VLSI faults, you'd better find out more about the L210i. Write Teradyne, 321 Harrison Avenue, Boston, MA 02118. Or call Daryl Layzer, L200 Product Group, 617/482-2700, ext. 2808.

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CIRCLE NO 67

SIGNALS & NOISE

Japan's defense role

I disagree with nearly all the statements and suggestions in Jon Titus's September 3 editorial "Increase Japan's defense role" (EDN, pg 53).

One reason Japan is a leading nation is that it does not waste its budget on unproductive military projects. Instead, it funds industry research, which turns out products and know-how that let Japan's industries increase their lead in so many areas.

If Japan was concerned enough about its defense role so that it, too, ordered an embargo of its state-of-the-art high-tech products, US companies would suffer the most. Japan is ahead in several key technologies, which it exports to the US and which are highly welcome there, if my impression is right. Like the US, it could use an embargo as a protectionist measure to prevent foreign companies from selling products that contain Japanese-made components and that would compete with Japanese-made goods.

I have a suggestion on how US companies can open Japanese markets: Develop suitable products! The Japanese market is not nearly as protected or nationalistic as the US and Europe seem to believe. Why do German car makers achieve double-digit growth in Japan by selling high-priced cars, while American cars lose out? My company, a small German instrument manufacturer, sells its products in Japanese markets where no American companies even try to compete. Sometimes, one gets the impression that America feels offended from all sides, and tries to make up for this by building stronger armed forces.

The Japanese people are very open to foreign products. They often prefer foreign products to goods produced in their own country, if those products are what they wish! There are examples of American companies succeeding in Japan. I read an article about an American manufacturer of home-fitness and body-building equipment that, after a hard start-up phase in Japan, is now more successful there than it was in America.

The Japanese select the product with the required performance and backup. A number of American high-tech companies sell to Japan by understanding this. Even today, years after Japanese companies took over the leadership in chip technology, a good part of the manufacturing equipment for these very chips is of American origin.

Wolfgang Schweitzer
Langenbach, West Germany

Correction

In the October 1 Special Report (EDN, pg 142) on surface-mount connectors, the quantities listed for the AMP products in the table on pg 146 should be thousands (not millions).

Clarification

The Special Report on digital storage oscilloscopes (EDN, October 15, pg 90) states that according to the Nyquist criterion, designers need to sample "at a frequency that's at least twice the highest frequency that interests" them. More precisely, designers must sample at a frequency at least twice as high as the highest frequency component that has an amplitude greater than the A/D converter's least-significant-bit weight.

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CIRCLE NO 68

DIGITIZING

1 1 GHz. The 11402 Digitizing Oscilloscope features a full 1 GHz bandwidth right on the probe tip to help you make the most demanding voltage and timing measurements.

2 10-14 BIT VERTICAL/ 10 ps HORIZONTAL RESOLUTION. 10-bit vertical resolution is averageable to 14 bits. Self-calibration decreases error to less than 1% DC.

3 AUTOMATIC MEASUREMENTS. Up to six measurements can be made at the push of a button, with results simultaneously displayed and continuously updated.

4 PUSH-BUTTON HARD COPY. Plug in a Tek or compatible Epson dot matrix printer using the scopes' standard Centronics port.

5 AUTOSET. Push a button on the front panel or on the probe to automatically set up the scope based on the signal characteristics of the selected trace.

6 TOUCH SCREEN. Select a trace, a trigger, a measurement or other function by touching the appropriate area of the screen or by selecting from pop-up menus: the closest, most natural link yet between user and scope.

Tektronix introduces the 11000 Series: the new standard in digitizing and analog oscilloscopes.

These new fully programmable scopes display more traces (up to 8) at higher bandwidths (up to 1 GHz), with greater accuracy (up to 0.6% vertical), and include more new functions for expediting the capture and processing of data than can ever be listed here.

Two new digitizing scopes exert the power of three 16-bit processors, long records, the most powerful triggering and the highest throughput ever. Use their built-in dual time-bases to easily acquire pre- or post-trigger details of a trace, and view both the whole trace and the details on screen at once.

Two analog scopes feature an integrated 500 MHz universal counter/timer for unequaled resolution, accuracy, and scope versatility— for the

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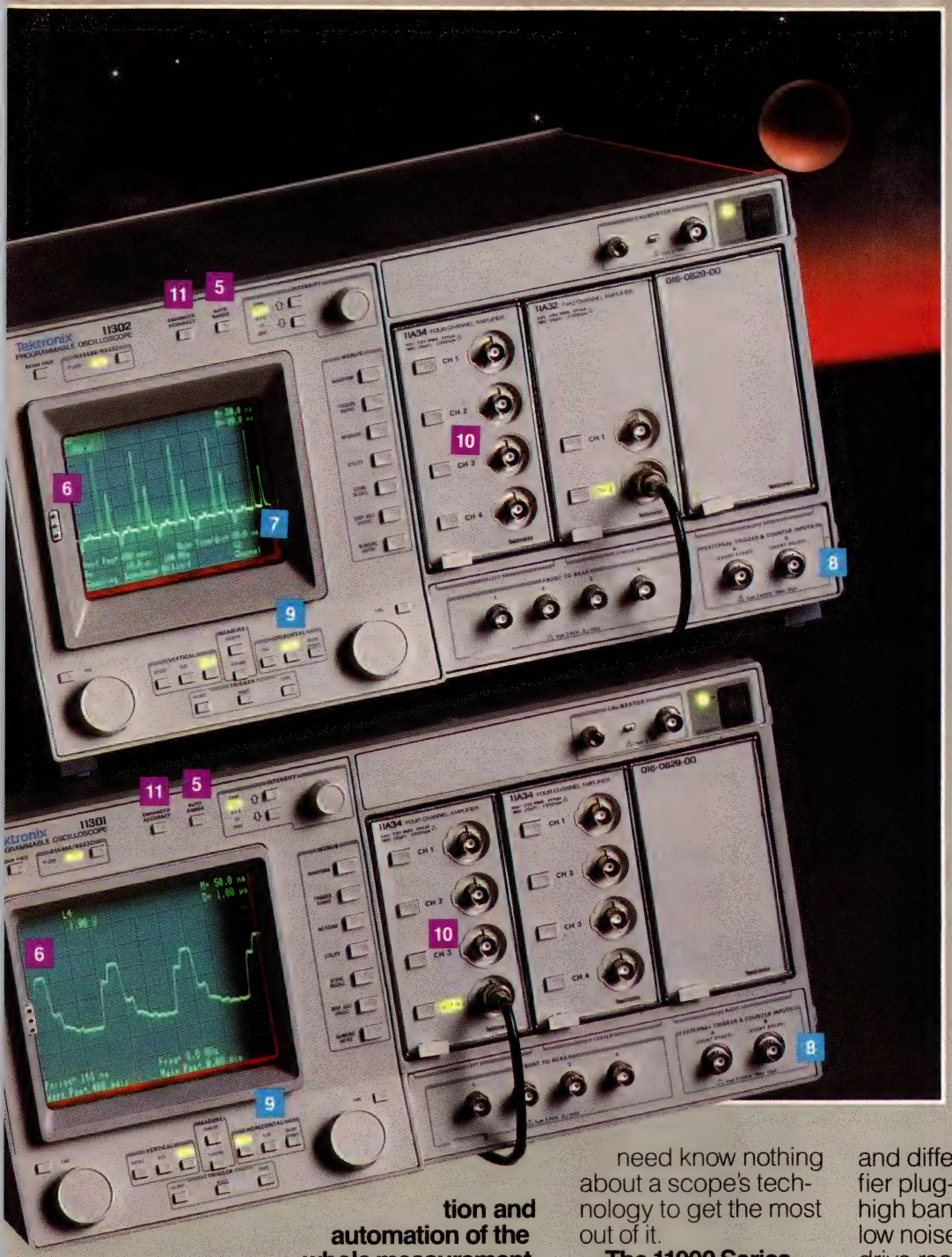

ANALOG

7 MICROCHANNEL PLATE. The single shot trace brightness of the Tek 11302 is almost 1000 times brighter than conventional scopes—enough to expose even the fastest transients to view.

8 500 MHz INTEGRATED COUNTER/TIMER. Use with dual delayed sweeps for precise timing measurements between selected points. Unique counter view trace lets you see exactly what you are triggering on.

9 CURSORS. Use to make precise measurements on any part of a displayed waveform.

10 1 mV/DIV SENSITIVITY. Achievable from four new plug-ins. These amplifiers feature fast overdrive recovery and wide dynamic range.

11 SELF-CALIBRATION. Push the Enhanced Accuracy button to calibrate the scope from amplifier input to CRT graticule, automatically, for the best vertical accuracy available in a scope today.

price of a scope alone. A unique counter view trace lets you see exactly what you are triggering on, for a sense of confidence no conventional counter/timer can offer.

Perhaps most startling is the simplification and automation of the whole measurement and analysis process. Larger displays, pop-up and touch-screen menus, plus automated setup and measurement capabilities help unclutter the front panel and keep eyes focused on the display. For the first time, users need know nothing about a scope's technology to get the most out of it.

The 11000 Series continues the plug-in versatility of the Tek 7000 Series. Five new plug-ins and three new probes tailor the new scopes to a full range of applications, from design and debug to production test. New single-ended amplifier and differential amplifier plug-ins combine high bandwidth with low noise and fast overdrive recovery.

Demonstrations are now in progress. For more information or a personal demonstration, get in touch with your local Tek sales engineer. Or call Tektronix at 1-800-547-1512.

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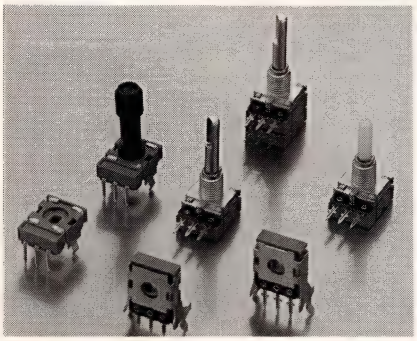
Customized miniature carbon and cermet potentiometers offer a range of options



Our new PP12 range of customized, miniature potentiometers comprises carbon types with logarithmic resistance ranges and cermet types with linear resistance ranges. A variety of accessories is available to support the devices. The potentiometers can be customized to suit specific requirements. The carbon types are aimed at consumer applications – for example audio – and the cermet types at high-quality professional applications – such as telecommunications and measuring equipment. With prices matching those of Japanese competitors, the PP12 range gives a European source for a product that has long been dominated by Far Eastern manufacturers.

The carbon types in the range have logarithmic resistance characteristics and a high mechanical endurance of between 10 000 and 25 000 cycles for consumer applications. The cermet potentiometers are linear, and withstand 50 000 operational cycles in professional applications. The devices are accurately specified; the linear potentiometers, for example, are accurate to within ±6 % at the central position.

The devices suit vertical or horizontal mounting, and can have single or tandem drives. They may be supplied as complete units with integral metal or plastic shafts, or as modules (with an optional plastic snap-in shaft). The modules are stackable, may be fitted with single-pole single-throw switches, and can have a tap terminal.

CIRCLE 9

HCMOS digital PLL filter provides cost-effective, accurate performance

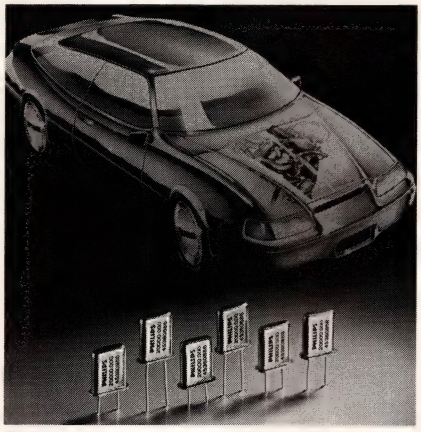
The latest addition to the Philips High-speed CMOS (HCMOS) logic family, the PC74HC/HCT297, is a digital phase-locked-loop filter which provides a simple, cost-effective solution to high-accuracy digital applications without the need for external analogue components. The circuit is for use in such areas as: very high Q filtering, higher order digital filters (Kalman filters); realtime control of bandwidth and centre-frequency (microprocessor control); bit synchronization; time-sharing applications; high-order loops by simple cascading; moderate frequency, very high resolution PLLs; applications in electrically-noisy environments battery-operated systems.

Like all the other members of our HCMOS family the new IC is available in CMOS-compatible (HC) and LSTTL-compatible (HCT) versions. The devices contain all the necessary circuits, with the exception of the devide-by-n counter and oscillator, to build first-order phase-locked-loops (PLLs) and are easily cascadable to build higher order loops.

These low-power versions of the LS297 PLL filter feature programmable variable bandwidth and centre frequency, direct digital readout of phase and phase-rate data, very low power requirements, low sensitivity to environmental changes and very high phase stability. Also there are simple digital methods of ripple cancellation, which are not available in equivalent analogue loops.

CIRCLE 48

Ranges of automotive, consumer, and industrial quartz crystals feature space-saving package



Philips is introducing ranges of quartz crystals for automotive and consumer applications in the miniature RW-80 encapsulation, which has just one-fifth the volume of the RW-43 package which it replaces. The crystals - the first ever automotive and consumer types available in RW-80 - have a range of fixed frequencies between 8 and 20 MHz. Complementing these standard frequencies are a range of crystals for industrial applications, with frequencies that can be customized anywhere between 8 MHz and 250 MHz.

The crystals have a rugged construction, the crystal blank being completely supported, leading to excellent resistance to shock and vibration. The RW-80 package, just 9 mm high, is hermetically sealed and resistance welded. All of the devices are assembled automatically, rather than with traditional manual assembly, still used for many competing crystals. The industrial versions are in a variety of RW-80 packages, including glass types with very stable ageing characteristics - demonstrated by a frequency change over a three month period of just 0.5 ppm under test conditions.

The crystals provide a reference frequency for ICs that is accurate down to ± 20 ppm of the specified value, with ± 5 ppm available on special request. The tolerance across the working temperature range is within ± 15 ppm, and the resonance resistance is a maximum of only 40 Ω. The devices have a load capacitance between 12 to 30 pF, and work between −40 and +115 °C.

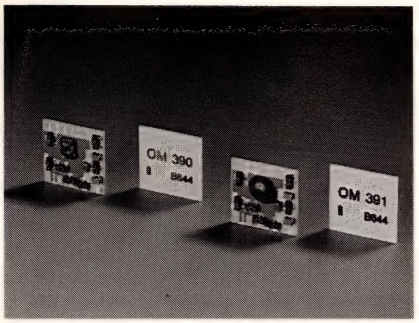
CIRCLE 87

PHILIPS

THE COMPLETE COMPONENT COMPANY

Philips Electronic Components and Materials Division, 5600 MD Eindhoven, The Netherlands

Smaller hybrid circuits dramatically reduce the length of proximity detectors



Two new hybrid ICs are small enough to mount transversely in proximity detectors having coils 20 mm in diameter or larger, and therefore dramatically cut the length of these detectors. The OM390 and OM391 measure just 14 by 14 by 1.7 mm and produce a proximity detection operating distance of between 2 and 5 mm, depending on the coil.

The OM390 and OM391 are for such application areas as positioning of machine tools, limit switches, component detection during assembly, and detection of coins in slot machines. By allowing manufacturers to use a shorter tube, the devices open up the possibility of new application areas where space is a critical factor and in addition reduce manufacturing costs.

Each circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, and an output stage. They have protection circuits against short-circuit and overload, voltage transients, and reverse-polarity connection. When actuated, the circuit passes an output current up to 250 mA through the load (such as the coil of an electromagnetic relay, an LED, or a photocoupler); two extra terminals connect to an optional indicator LED.

The thin-film circuits fit in M18 hollow-stud assemblies (when they are mounted longitudinally) or M30 (for transverse mounting). They accept a supply voltage between +10 and +30 V (OM390) or −10 and −30 V (OM391), and consume typically 0.4 W from a 24 V supply.

CIRCLE 126

Image intensifier offers third-generation features at a second-generation price

With a price tag of US$ 4500, the Philips XX1610 'second-generation super' proximity-focused image intensifier offers third-generation night vision performance at a second-generation price. The new device suits night-viewing systems for military and security surveillance applications.

The new image intensifier has a sensitivity and signal-to-noise ratio double those of currently available second-generation types and works right down to starlit or clouded moon conditions, still producing an illuminance of 10^{-4} lux. In addition, it has an operational lifetime three times that of other second-generation intensifiers. It operates with the objective lenses and other accessories of second- and third-generation image intensifiers.

Minimum sensitivity is 500 μA/lm, compared with the 240 μA/lm of other second-generation devices. Although third-generation intensifiers have a higher sensitivity of 1000 μA/lm, they cost more than twice as much as the XX1610, and will anyway not be generally available until 1990. Furthermore the XX1610 has a signal-to-noise ratio of 15.5 which matches that of third-generation types.

Light entering the intensifier is collected through a clear-glass anti-veiling glare input window, onto an S20R red-extended photocathode. The electrons generated by this photocathode are multiplied by a microchannel plate which incorporates a proprietary treatment that gives a long 3500 hour operational life – again matching third-generation intensifiers.

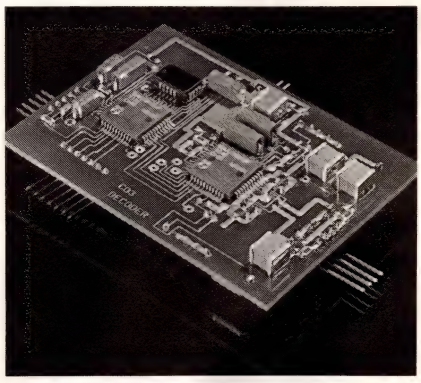
CIRCLE 165

Compact Disc decoding circuits halve IC parts count, use less power, extend temperature range

We are unveiling a pair of third generation Compact Disc ICs for high-performance low-cost systems that forms a complete stereo CD decoding system – instead of the four ICs previously required – with very few other components. Particularly attractive to portable equipment, the CMOS SAA7310 and SAA7320 have a much lower power consumption – typically 475 mW combined – than second generation NMOS ICs, and allow the whole decoding system to be run from a single +5 V supply. The devices also operate over a wider temperature range of −40 to +85 °C which is of great importance in automobile applications.

The SAA7310 decoder incorporates all the functions available on the well-known SAA7210, such as demodulation, error correction and basic interpolation. In addition there are extra functions: a special mode for non-digital audio applications – for example CDROM and CD Interactive – prevents data from being interpolated (and thus corrupted), a strong requirement for such applications; and improved playability for applications where mechanical shock is likely to occur, such as portable players and in-car systems.

The SAA7310 and SAA7320 are both available in a 44-pin quad flat-pack. In addition, the SAA7310 is also available in a 40-pin DIL which can be used as a replacement for the SAA7210.



CIRCLE 204

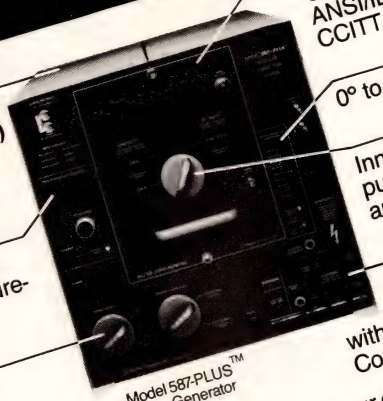
PHILIPS

Surge Testing Is Now Routine and Affordable for Final Test and Service Departments.

Two new surge generators (587 and 587-PLUS) starting priced below $20,000 and built for routine use.

Built-in SurgeSense™ permits voltage measurement at the EUT.

SAFE, reliable high voltage switching.



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Can be configured to meet ANSI/IEEE, IEC, UL and CCITT standards.

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Innovative Bi-Wave™ pulses are real world and quantifiable.

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CIRCLE NO 4

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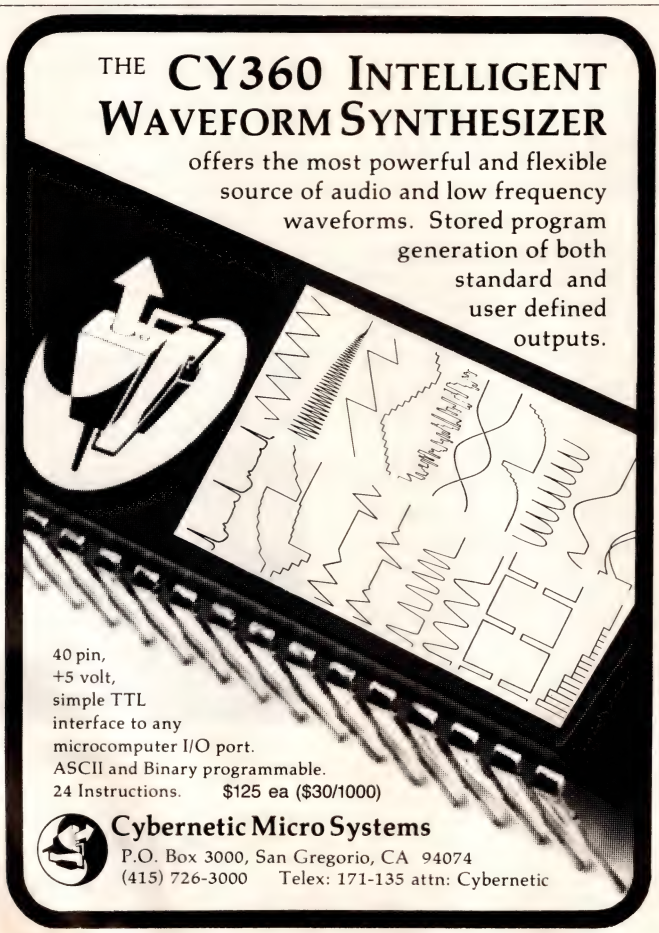

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CIRCLE NO 5

CALENDAR

Third Annual Technical Symposium on Optoelectronics and Laser Applications in Science and Engineering, Los Angeles, CA. SPIE, Box 10, Bellingham, WA 98227. (206) 676-3290. January 10.

ATE and Instrumentation Conference West, Anaheim, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126. January 12 to 14.

Third Annual Battery Conference on Applications and Advances, Long Beach, CA. Cecile Duong, Department of Electrical Engineering, California State University at Long Beach, 1250 Bellflower Blvd, Long Beach, CA 90840. (213) 498-4605. January 12 to 14.

Designing Real-Time Hardware for Digital Signal Processing (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 12 to 15.

Real-Time Operating Systems (short course), San Diego, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 12 to 15.

Annual IEEE Design Automation Workshop, Apache Junction, AZ. Walling Cyre, Control Data, HQM 173, Box 1249, Minneapolis, MN 55440. (612) 853-2692. January 13 to 15.

Conference on Optical Fiber Communication (OFC '88), New Orleans, LA. Optical Society of America, 1816 Jefferson Pl NW, Washington, DC 20036. (202) 223-0926. January 25 to 27.

Annual Reliability and Maintainability Symposium, Los Angeles, CA. V R Monshaw, RCA, Astro Electronics, Box 800, MS 55,

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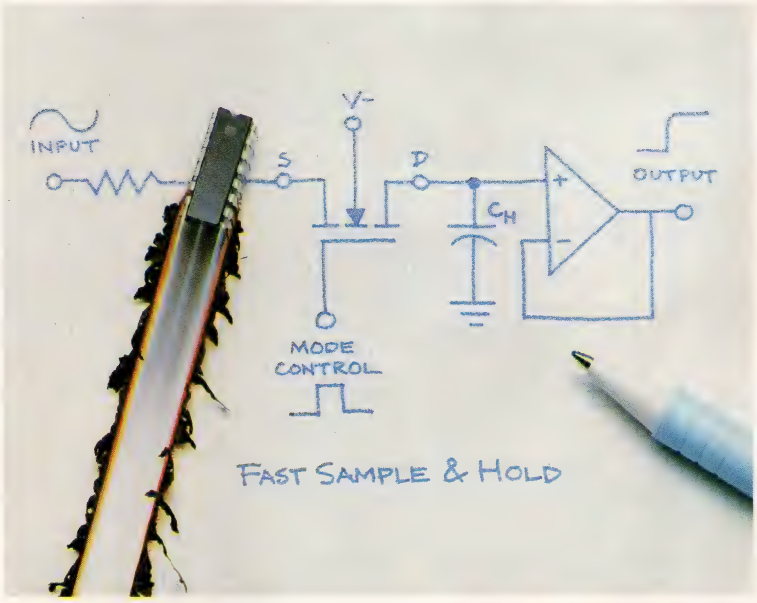

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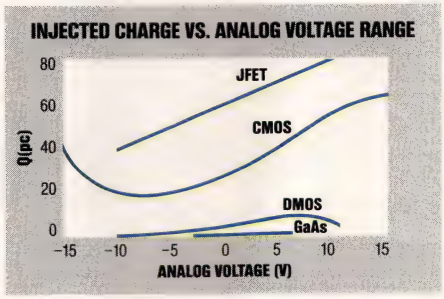

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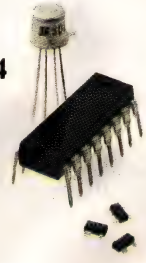

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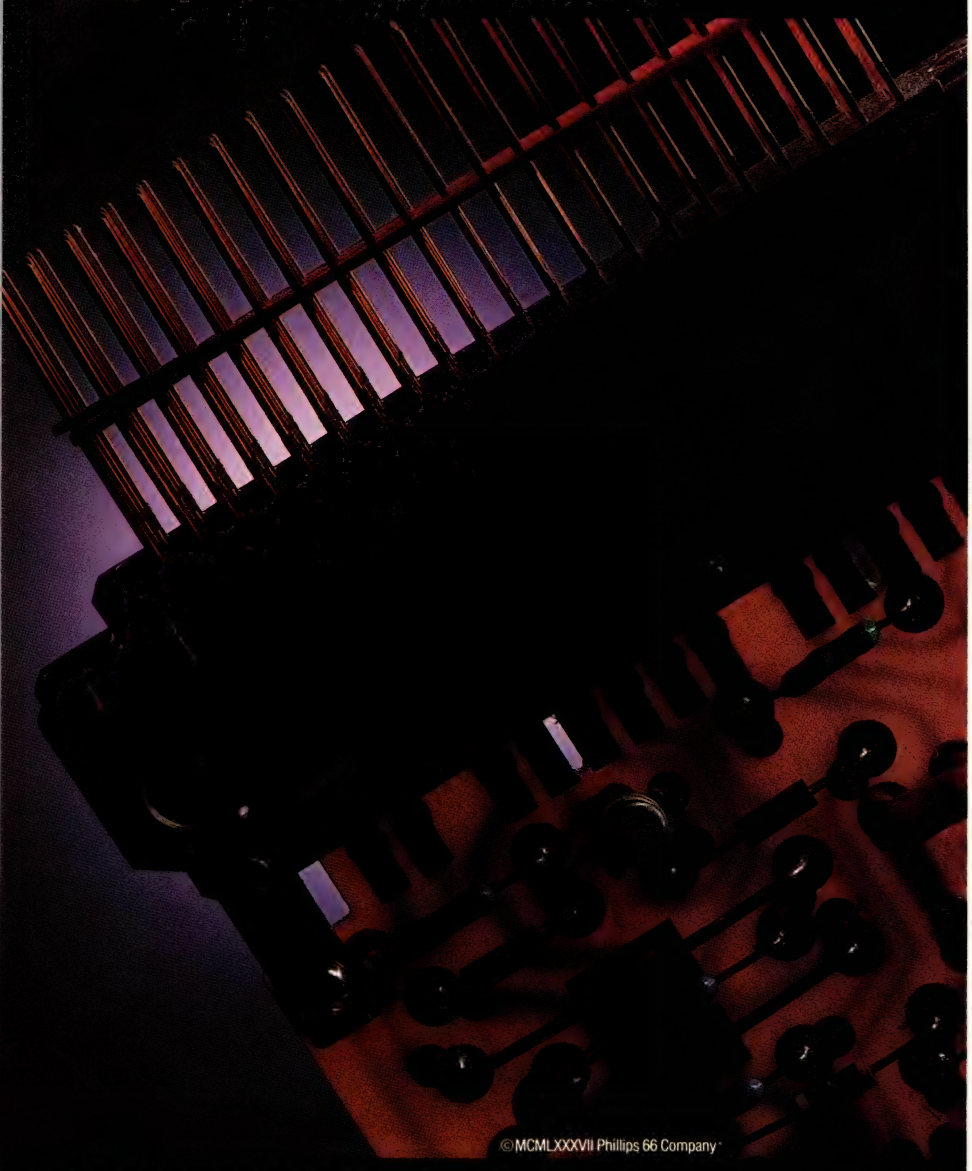

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CIRCLE NO 6

CALENDAR

Princeton, NJ 08540. (609) 426-2182. January 26 to 28.

Designing Real-Time Hardware for Digital Signal Processing (short course), Montreal, Canada. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 26 to 29.

High-Performance Computer Architectures (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 26 to 29.

Microwave Circuit Design I (short course), El Segundo, CA. UCLA Extension, 10995 Le Conte Ave, Los Angeles, CA 90024. (213) 825-3344. February 1 to 5.

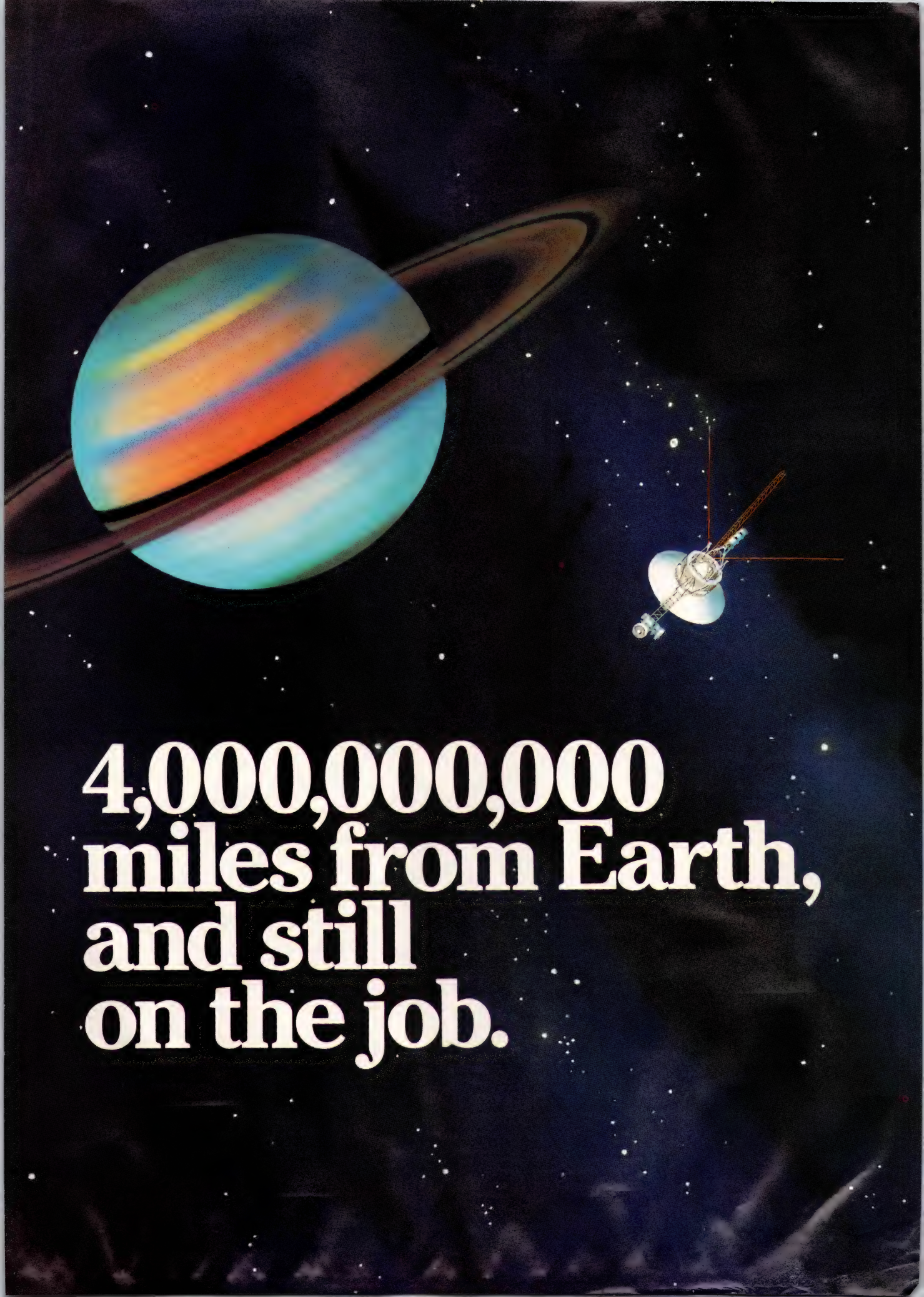
High-Performance Computer Architectures (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. February 2 to 5.

Microwave Circuit Design II (short course), Los Angeles, CA. UCLA Extension, 10995 Le Conte Ave, Los Angeles, CA 90024. (213) 825-3344. February 8 to 12.

Unix Technical Conference, Dallas, TX. Usenix Conference Office, Box 385, Sunset Beach, CA 90742. (213) 592-1381. February 9 to 12.

Semicustom Circuit Program Conference, San Diego, CA. Mackintosh Consultants, 209 W Central St, Natick, MA 01760. (617) 655-0001. February 17 to 19.

Software Development '88, San Francisco, CA. Miller Freeman Publications, 500 Howard St, San Francisco, CA 94105. (415) 995-2426. February 17 to 19.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- Logging the existence of volcanoes on the Jupiter moon Io
- Photographing Saturn's complex ring system
- Recording the many moonlets that surround Saturn

Just last year, Voyager 2 surveyed Uranus and discovered 10 new moons orbiting in its system. Ahead lies an encounter with Neptune in 1989. Beyond that, Voyager 2 will leave the solar system and journey the dark oceans of space, perhaps to meet another solar system, perhaps other beings.

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- **IUS:** HI-562A converters; HI-507A multiplexers
- **Magellan:** HM-6516 RAMs
- **Intelsat:** HA-2700 op amps
- **Mariner, Skylab, Shuttle** and nearly 100 similar programs.

To those who dreamed of exploring space and to those who achieved it: we salute you and look forward to teaming up with you in the future.

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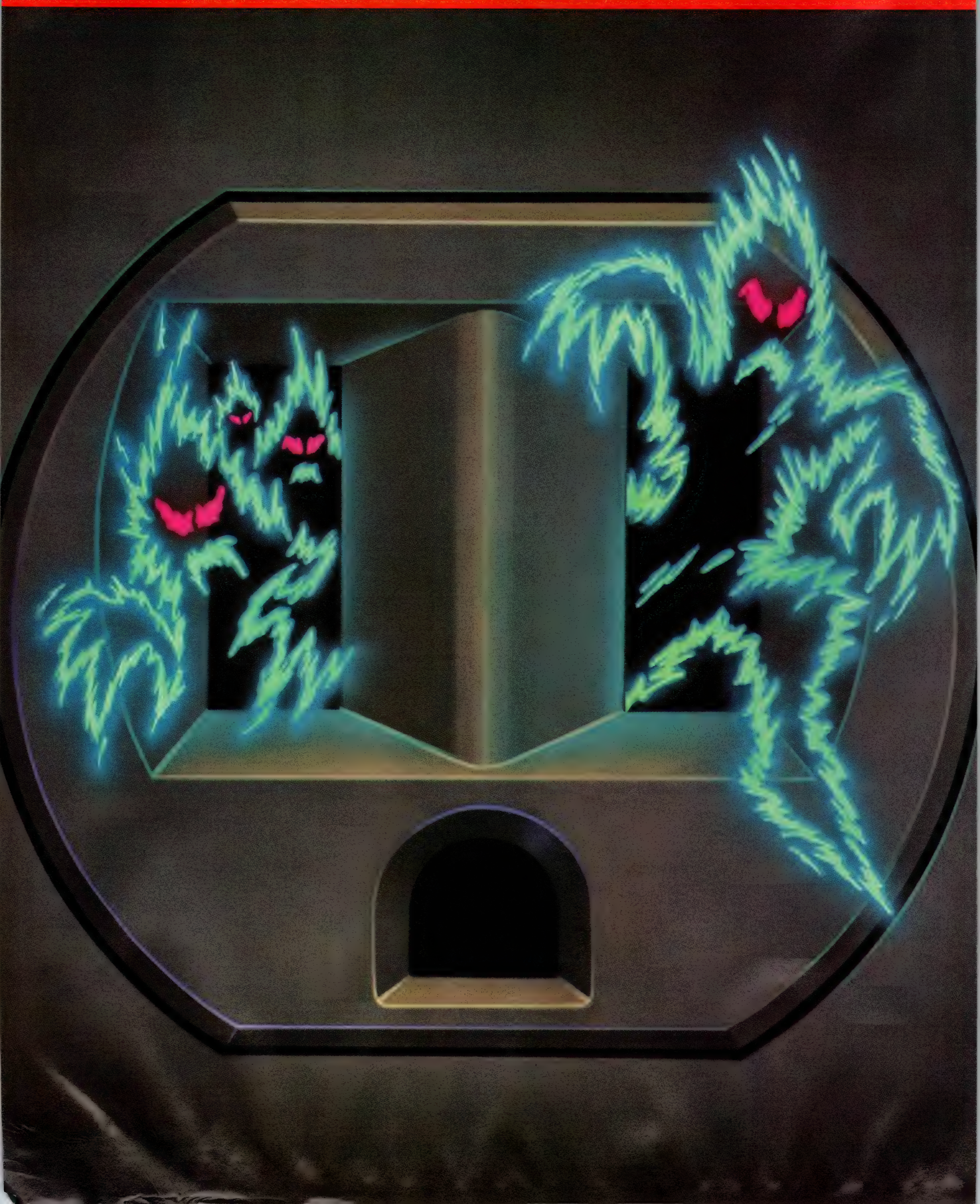
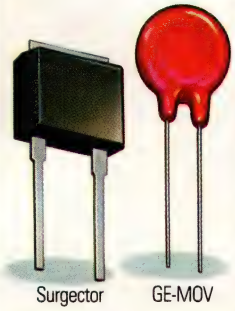
CIRCLE NO 38

Suppress those



nasty little surges.

With Surgector™ and GE-MOV® surge suppressors.

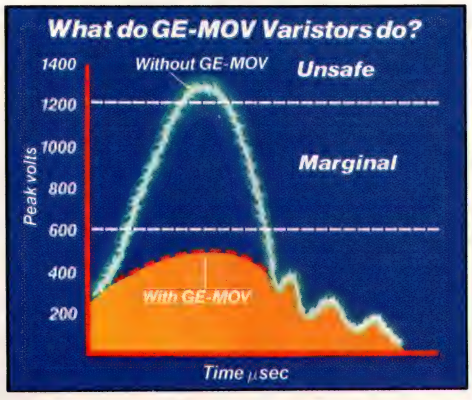


Now, whether you're designing small consumer products, industrial controls, high-rel military and aerospace systems, or anything in between, we have a surge protection solution for you. Because if one of our GE-MOV varistors isn't exactly right for the job, then one of our Surgectors probably will be.

Leader in Varistors.

We have the broadest line of varistors in the industry, with a range from 5V to 3500V, including the highest-energy MOV's in the industry (up to 70,000 peak amps and 10,000 joules).

They're widely used for incoming ac line protection in power supplies, clamping circuits and low voltage supply protection.



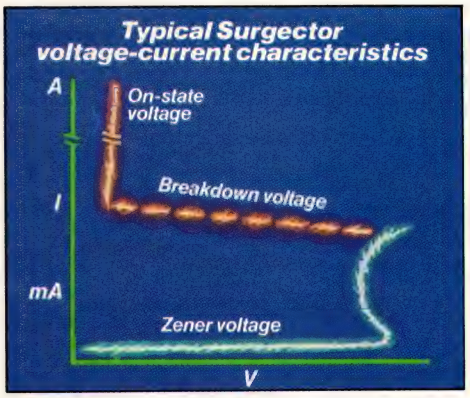
They're available in a variety of packages, including axial leaded, radial leaded, leadless surface mount, high-energy modules and connector-pin configurations. And they're all available for fast delivery.

Inventor of Surgector devices.

Surgector devices respond rapidly and handle a lot of energy. So they're ideal for protecting sensitive or expensive components from lightning strikes, load changes, switching transients, commutation spikes, electro-static discharge and line crosses.

How they work.

Surgector devices combine a zener diode and an SCR into one reliable, cost-effective device.



At low voltages, the Surgector is "off," representing high forward impedance (only 50nA leakage current). The instant clamping voltage is exceeded, the Surgector turns "on" and the zener immediately starts conducting. Within nanoseconds, the SCR turns on to handle heavy currents. Destructive surges are shunted to ground.

Once the surge passes, the device makes a fast transition back to the "off" state. You can choose from two-terminal, three-terminal or bi-directional devices.

We'll help you decide.

To determine which of these powerful technologies is best for you, plug into our applications hotline and let our experts help you decide.

For more information, call toll-free 800-443-7364, extension 21. Or contact your local GE Solid State sales office or distributor.

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Testing devices with as many as 512 pins is no challenge for the DIC-9035B. And it can test at rates up to 200MHz in Multiplex mode, and still maintain an overall timing accuracy of ± 500ps.

ASIC testing is much more cost-effective because the DIC-9035B can perform parallel test functions and provide long real-time pattern generation (512k words), even with DC/pin architecture.

Because this system includes powerful analysis software, the DIC-9035B can be connected directly into your CAD system and/or EWS via Ethernet*. This provides instant, accurate feedback on problems to the design level, minimizing the turnaround time needed to bring an ASIC from R&D to full production.

There are three models of the DIC-9035B covering the whole range of testing to choose from: a $12V_{p\text{-}p}$ station for MOS, a $2.5V_{p\text{-}p}$ station for ECL, and a low-capacitance station for CMOS.

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CIRCLE NO 42

Think big

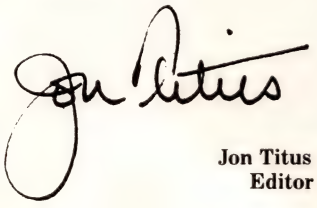
An American automobile-company executive once remarked that if his company had one fault it was the failure to think big enough. In other words, the company could have exploited many situations if it had thought big and executed big plans. That man's comment came back to me recently when I read an old brochure describing Radio Shack's TRS-80 Model I computer—now about 10 years old. I couldn't help comparing the progress of Radio Shack with that of its rival, Apple Computer. The major difference that comes to mind is that Apple's founders, Steve Jobs and Steve Wozniak, thought big. Executives at Tandy didn't. Today, the results are obvious.

While Tandy hedged its bets, assuming that only a thousand computers would sell, and never sure who would buy them, Wozniak and Jobs knew they'd sell many thousands of computers, and they had a good idea of who their customers would be. Both computer companies started in the same position and with similar technical resources. Both companies used off-the-shelf components—Tandy chose the Z80 μP; Apple chose the 6502 μP. (Contrary to popular computer mythology, neither company was the first to market a personal computer. Companies such as Processor Technology, Sphere, and Commodore fielded earlier PCs, but those companies didn't think big, and their sales faltered.)

There are still opportunities for people who think big. But instead of doing so, many engineers tell themselves that there will never be another company like Apple—so why bother trying to duplicate its success? They forget, however, that people don't get rich by following the paths of others.

I've been brainstorming and have come up with two new-product opportunities worth exploring: the telephone and the photocopier. First, I'd like a small printer on my phone—one that could receive simple messages from phones with similar equipment. How I wish I could send secretaries my name and phone number rather than repeating it countless times each day.

But I'd like a small copier even better. Several companies already offer personal copiers, but because a copier, laser printer, scanner, and facsimile machine are so similar, let's have a unit that embodies all their functions. Such a machine could send and receive documents, copy papers, and convert articles to ASCII files for editing. It's sure fun to think big. But it must be even more fun to put big thoughts into action.



Jon Titus
Editor

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Most important, while the Volksclosure costs less, you don't get less. It fully reflects Electronic Solutions' commitment to quality and performance. For example, it meets UL and CSA safety standards and FCC Class A EMI/RFI specs to the letter.

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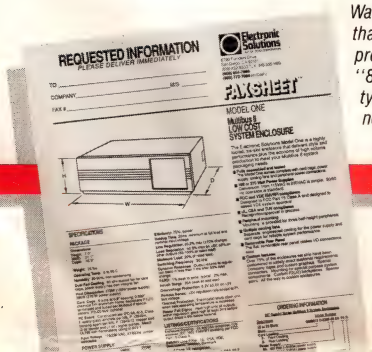

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CIRCLE NO 43

Workstations perform 300,000 vector transformations/sec

By using a graphics accelerator, the HP 9000 Model 330CHX and Model 350CHX graphics workstations can perform 250,000 and 300,000 vector tranformations/sec, respectively. This short graphics-response time allows for fast screen updates and smooth pan and zoom operations.

The HP 98556A graphics accelerator, which comes with Models 330CHX and 350CHX, performs the vector transformations in hardware; thus, it provides an integer-based world-coordinate interface directly to the graphics hardware.

The HP 98556A employs an MC68020 as a dedicated graphics-processing unit (GPU) that manages the accelerator's graphics pipeline. The accelerator uses an integer-math chip to implement a 2-D transform engine for the math-intensive transform calculations needed for scale, translate, rotate, and clipping functions. The GPU also supports cursor tracking and operations, eliminating the substantial system overhead normally associated with these functions. By providing hardware support for context switching and clip-list management, the GPU also improves the performance of software windows. The accelerator operates in multiple obscurable and movable windows by using the vendor's HP Windows/9000 window manager.

The Model 350CHX workstation includes a 25-MHz, 68020-based CPU; an MC68881 math coprocessor; a 1280×1024-pixel, 19-in. color monitor with eight color planes and two overlay planes; the 98556A graphics accelerator; 8M bytes of memory; a keyboard; a mouse; and an ID module. It costs $38,550.

The Model 330CHX's CPU, also based on the 68020 μP and accompanied by a 68881 math coprocessor, runs at 16.6 MHz. The 330CHX has a 16-in., 1280×1024-pixel color monitor with eight color planes and two overlay planes; the 98556A graphics accelerator; 4M bytes of memory; a keyboard; a mouse; and an ID module. It sells for $22,250.

***The 300,000-vector/sec graphics-performance rate** offered by the HP 9000 Model 350CHX translates to a reaction time of approximately 0.25 sec in applications such as pc-board design.*

The HP 98556A graphics accelerator is available as an add-on product for the vendor's Model 330CH and 350CH workstations; it costs $6000.—***Jim Wiegand***

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CIRCLE NO 7

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68000: UNIX System V
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PowerNode: UTX/32

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VAX, VMS, PDP-11, ULTRIX: TM of Dig. Equip. Corp.
TNIX: TM of Tektronix Inc.
VENIX: TM of VenturCom
PowerNode, UTX/32: TM of Gould Inc.

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CIRCLE NO 8

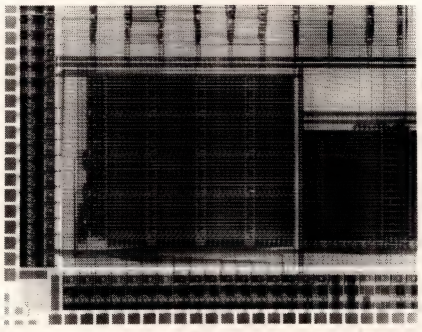
Gate arrays feature 100,000-gate capacity

The LCA100K Compacted Array Plus family of gate arrays is the first array-based family of HCMOS ASICs to provide 100,000 usable gates on a chip, which is more than twice the density of other currently available gate arrays. The vendor achieved this level of integration by developing a proprietary, 3-layer metal-interconnect technology that allows for 0.7-μm channel lengths.

The arrays let you put significant amounts of high-density memory and logic on the same chip. For example, these gate arrays let you combine 16k bits of static RAM (having access times under 15 nsec), 64k bits of ROM, and 46,000 usable logic gates (with gate delays of less than 460 psec through a 2-input NAND gate) on a single chip.

The most obvious beneficiaries of this level of integration are system designers, who can now consolidate a whole system on a single chip or, in the case of a more complex system, can reduce the number of circuits required to implement the system. To get an idea of the significance of a 100,000-gate array, consider the fact that the entire CPU logic of a VAX 11/780 could be implemented with 100,000 gates. The 100,000-gate technology will also allow designers to increase the overall performance and reliability of circuits and reduce their size and power consumption.

To manage the design of chips as complex as the LCA100K Compacted Array Plus, the vendor offers the Modular Design Environment (MDE) software tools. This software includes an interactive graphics interface and floor-planning tools, which are absolutely necessary for designing at this level of integration. MDE also has logic and memory compilers, libraries of functional building blocks ranging in complexity from the SSI to the VLSI level, and hardware accelerators. Behavioral, gate-level, and multichip simulators for the support of system-level architecture are also included in MDE.



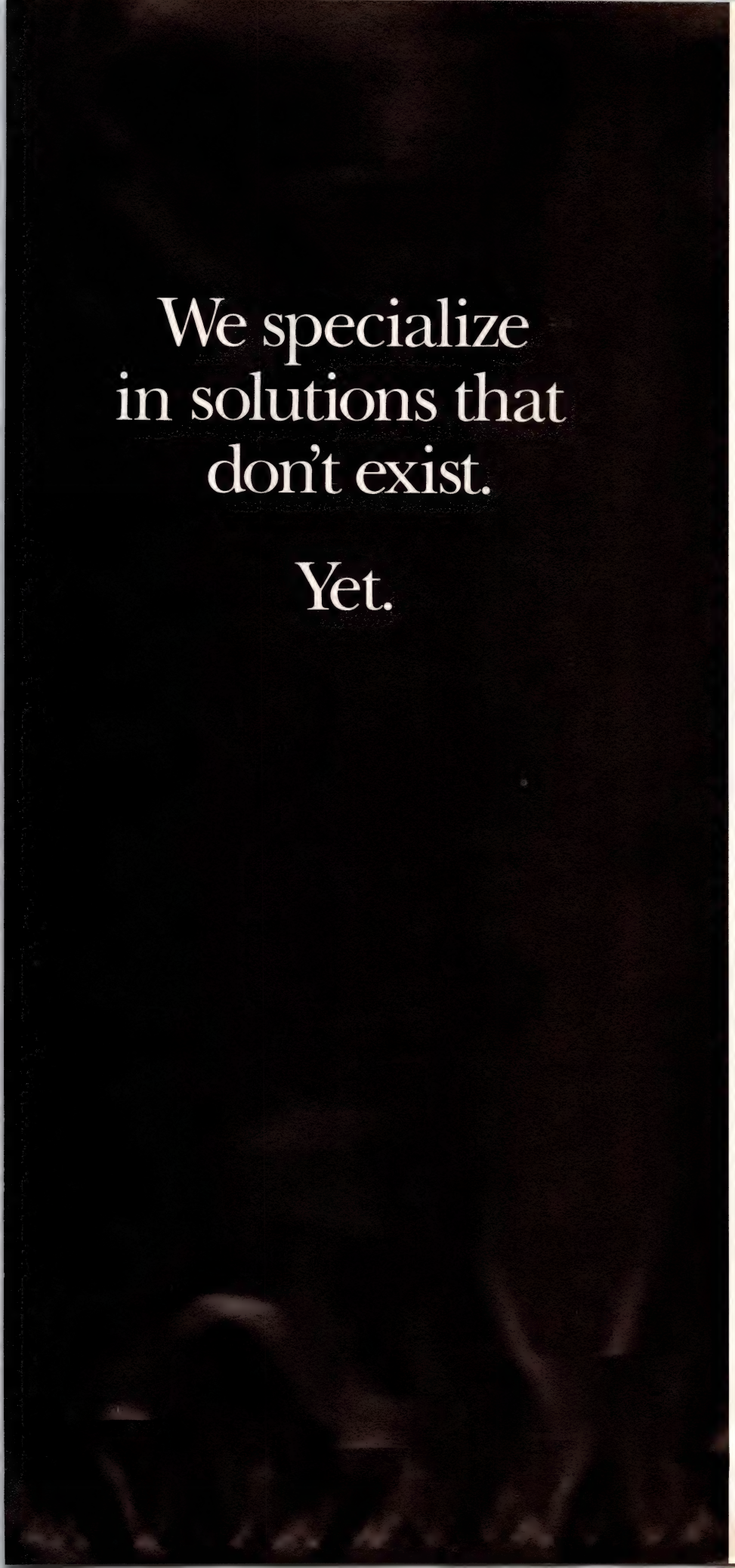
The LCA100K Compacted Array Plus gate arrays *combine 0.7-μm channel lengths with 3-layer metal interconnects to provide as many as 100,000 usable gates per IC.*

The LCA100K Compacted Array Plus family consists of three master slices that contain 139,104 to 236,880 gates. These arrays allow you to implement designs of 50,000 to 100,000 gates. As many as 344 signal I/O pads are available for these devices. The arrays also have eight pads that are dedicated to V_{DD}, and 12 that are dedicated to V_{SS}. The vendor estimates the nonrecurring engineering cost for a 100,000-gate design to be $100,000.

—Jim Wiegand

LSI Logic Corp, 1551 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 433-7146.

Circle No 710



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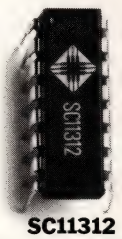
A-Law/Para
w/high output

SC11311
Combo CODEC
μ-Law/Serial
w/high output



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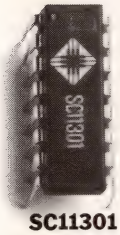
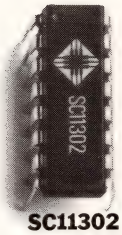


SC11301
Combo CODEC
μ-Law/Serial



SC11302
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A-Law/Serial

SC11305
Combo CODEC
μ-Law/Para

SC11320
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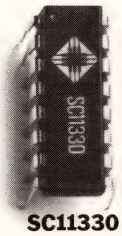

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Max. Clock Freq. (typ)J/K F•F (C_L = 15pF)	150MHz	60MHz	45MHz	2MHz
Quiescent Power Diss. (typ) (GATE)	0.01μW	0.01μW	8mW	0.01μW
Noise Margin $V_{IH(min)}/V_{IL(max)}$	3.5V/1.5V	3.5V/1.5V	2.0V/0.8V	3.5V/1.5V
Output Current $I_{IOH}I_{(min)}/I_{OL}$ (min)	24mA/24mA	4mA/4mA	0.4mA/4mA	0.12mA/ 0.36mA
Op. Volt. Range	2-6V	2-6V	4.75-5.25V	3-18V
Op. Temp. Range	-40-85°C	-40-85°C	0-70°C	-40-85°C

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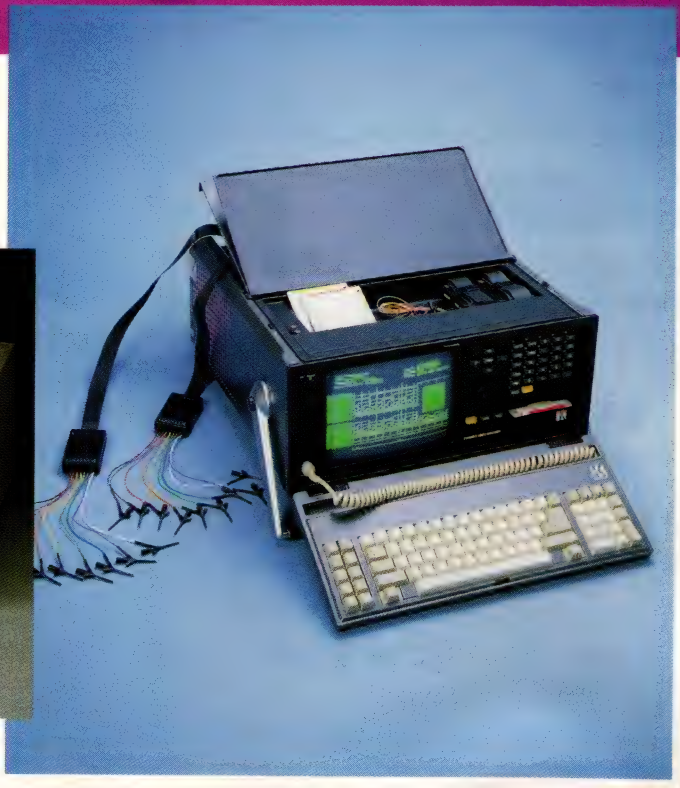
CIRCLE NO 45

Logic analyzer that supports as many as 400 channels *(Hewlett-Packard)*

High-performance logic analyzer *(Tektronix)*



Portable-PC-based logic analyzer with optional pattern generator *(Kontron)*

Consider logic analyzers for more than μP applications

Logic analyzers, which are well known to engineers who troubleshoot μP-based systems, can also help you solve hardware and software problems with other digital systems. You'll get the best analyzer for your money if you carefully match the instrument's capabilities with your needs.

Doug Conner, *Regional Editor*

Logic analyzers are virtually mandatory for developing and troubleshooting microprocessor-based systems, but they can benefit other digital applications as well. A logic analyzer may be just what you need for developing digital systems in which you need to look at more than four signals at once. Not only do logic analyzers offer many input data channels, but they also provide selective triggering, which lets you capture just the event you want. Further, the subnanosecond timing resolution available on some logic analyzers means that you'll seldom have to turn to an oscilloscope for precision timing analysis.

Because logic analyzers vary widely in performance and price, you'll benefit by carefully matching logic-analyzer performance with your needs. When you choose an analyzer, the four most important features to consider are channel count, asynchronous sampling rate, synchronous sampling rate, and triggering capabilities.

Enough channels for trigger word and data

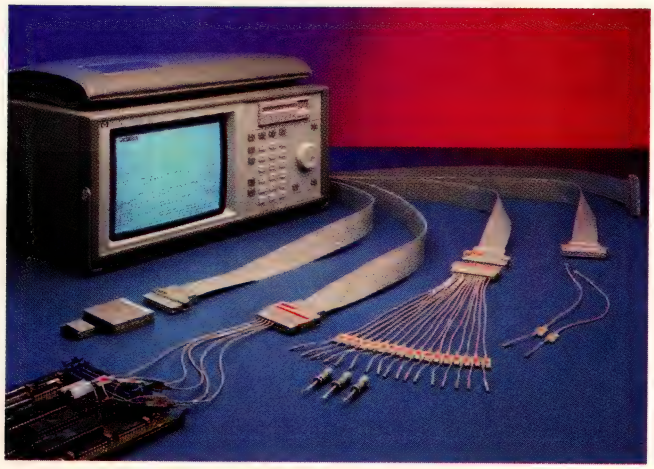
The number of channels you'll require from your logic analyzer depends on the number of signals you need to examine and the number of signals required for your trigger word. If your analyzer has more than the minimum number of channels required, you won't have to move probes as often. Further, when you troubleshoot bus-based systems, the extra channels will let you cover all the control lines as well as the data and address lines.

In systems that incorporate microprocessors, the μP often dictates the required number of channels. An 8-bit microprocessor would be well covered by a 32-channel machine; to probe every signal line of a 68000 μP would require about 60 channels. To troubleshoot interprocessor problems on a multiprocessor system, you'll need a machine with more than 100 channels. If you're looking strictly at the timing analysis of a circuit, and no microprocessors are involved, you may be satisfied with eight channels and a very fast asynchronous sampling rate.

Timing analysis for hardware problems

Asynchronous sampling (or timing-analysis mode) uses the logic analyzer's internal clock to determine when to sample. Because asynchronous sampling normally provides the best timing resolution, it is the mode that hardware engineers generally use to track down timing problems. A mid-performance logic analyzer typically offers a 100-MHz asynchronous sampling rate, which yields 10-nsec resolution. Although 10-nsec resolution may be sufficient for you to see when incorrect data has been clocked into a register, it's not very helpful when you're looking for such problems as data-

You may be able to use the logic analyzer's powerful external trigger to trigger your oscilloscope.



Logic analyzer with 100-MHz timing on 80 channels *(Hewlett-Packard)*

setup and -hold time violations. For sensitive timing problems, you'll need to turn to either a higher-performance logic analyzer or an oscilloscope.

Table 1 lists the salient specs for a representative sample of logic analyzers. Higher-performance models generally offer asynchronous sampling rates of 400 MHz and greater. Gould, Hewlett-Packard, Kontron, Outlook, and Tektronix, for example, all offer logic analyzers with asynchronous sampling rates in the range from 500 MHz to 2 GHz. Outlook's T100 uses an equivalent-time-sampling mode to obtain 100-psec resolution. Some logic analyzers even incorporate optional digital storage oscilloscopes (DSOs) for when you want to see what a waveform actually looks like. Even if you do need to pull out an oscilloscope to look at a particularly sensitive timing problem, you may be able to use your logic analyzer's powerful external trigger to trigger your oscilloscope.

Use state analysis to look at many channels

If your task is not to perform timing analysis but to follow the flow of data through a system, you'll want to look at the data only when it's valid. For this task, logic analyzers offer a synchronous-sampling mode (also called state-analysis mode or external clocking). By using a clock signal from the circuit under examination, along with some clock-qualifier control words, you can acquire data when it's valid. All logic analyzers typically display state information in binary, octal, decimal, hexadecimal, or ASCII form.

Midrange logic analyzers typically exhibit synchronous clock rates in the 25- to 50-MHz range. For microprocessor work, 25 MHz is adequate, because you'll generally operate the analyzer at the bus rate, which is seldom greater than 5 MHz. When you troubleshoot bit-slice architectures, reduced-instruction-set computers (RISCs), mainframe computers, or high-speed digital systems in general, your synchronous clocking requirements may exceed 25 or even 50 MHz. Tektronix's DAS 9200 offers a 200-MHz synchronous sampling rate while probing as many as 384 channels. Outlook's T100 will accept a 250-MHz external clock and 32 input channels.

To decide whether a particular logic analyzer has adequate speed for your application, you need to consider more than just the clock rate. Data-setup and -hold times and channel-to-channel skew can also be important. Although these parameters seldom pose a problem in general microprocessor work, they can be a limiting factor when you're examining digital systems having high clock rates.

A logic analyzer's data-setup and -hold times are specified by the manufacturer, and they normally apply only to external clocking. If the circuit under test violates the logic analyzer's data-setup or -hold times, you may acquire incorrect state data.

Also keep in mind that every logic analyzer exhibits some skew between channels. An analyzer's skew is not generally as well specified as its data-setup and -hold times, but it's still important. If your machine's data sheet doesn't list the channel-to-channel skew, call the manufacturer to find out. It's important to know the skew, because it can be responsible for incorrect state data. Even if your circuit's setup and hold times initially look correct on the logic analyzer, the skew may cause data on one channel to arrive later or earlier than data on another. Some of the higher-performance logic analyzers allow you to compensate for the channel-to-channel skew.

Whether you're using an analyzer's state- or timing-analysis modes, it's possible for more than one transition of a logic state to occur between samples. Most logic analyzers provide a glitch-detection function to catch this occurrence. As the term applies to logic analyzers, a glitch is typically defined as more than one transition of a logic signal between samples.

Logic analyzers vary as to how they detect and display glitches. Note two things, however. First, all analyzers specify the minimum pulse width that they can detect; they can't detect a shorter pulse even though it may be crashing your system. Second, some logic analyzers allow you to logically AND a trigger word with glitch detection so that the logic analyzer can

look for a glitch in an area known to be troublesome while the system runs continuously.

Many analyzers offer a variable threshold

A logic analyzer can also help you find intermittent problems in other ways; for instance, by using a variable threshold. Virtually every logic analyzer offers a fixed TTL threshold for determining whether an input is high or low. Many offer ECL and variable thresholds as well. If you enounter intermittent system failures, you may be able to make them easier to find by varying the threshold level.

A variable threshold is also useful for setting up the proper threshold levels when you're working with CMOS logic. Some logic analyzers, such as Kontron's PLA286, allow you to assign channel groups to different thresholds so that you can observe ECL and TTL signals on different channels at the same time.

When choosing a logic analyzer, be sure to look at the probes available for the machine. If the probe causes too much loading on a circuit, rise times could slow down enough to result in system timing problems. Some manufacturers combat this problem by providing active probes, which cause very little circuit loading. Active probes can have low input capacitance, but are often bulky in comparison with passive probes. Passive probes are satisfactory in most cases; what's more, they're less expensive and more rugged than active probes, but for the most demanding applications—such as high-frequency circuits or circuits with high output impedance—active probes may be necessary to preserve the signal bandwidth of the circuit under examination.

In some situations, you may need to start debugging a circuit before all the functional blocks are available. Many logic analyzers offer pattern-generation options (see **Table 1**) that allow you to provide digital stimulation to a circuit to simulate missing functional blocks. These pattern-generation options can provide a useful tool for verifying and troubleshooting circuits (see **box,** "Pattern generator speeds development cycle").

Triggering to capture the right event

For the person who must track down software or hardware/software problems with a logic analyzer, triggering features are all-important. You'd choose a logic analyzer over an oscilloscope for this task because logic analyzers have better triggering functions than scopes do. Logic analyzers are especially useful for triggering on complex problems that require you to look at multiple lines simultaneously.

Logic analyzer with 400-MHz transitional timing *(Philips Test & Measurement Instruments)*

For example, suppose you want to see what data is being written to a certain address in your μP-based system. Because your microprocessor is running a program, it is continuously accessing memory. To trigger on a specific address, the logic analyzer must monitor 20 address lines and trigger only when the correct address appears with a write-enable control signal. The trigger condition would be the correct data state for the 20 address lines plus the write-control lines. You could perform this task with an oscilloscope and a word-recognizer probe, but oscilloscopes can examine only two to four data lines at a time. A logic analyzer, in contrast, usually has 32 channels or more.

A logic analyzer's triggering function (or trace control, as it's also called) lets you logically combine an external clock input with other signals called clock qualifiers. Triggering thus allows you to clock data in from multiplexed data/address lines by setting up two enable conditions. One set of probes and a clock qualifier latch in the address, and another set of probes and a clock qualifier latch in the data. With some logic analyzers you must resort to double probing of the channels, which doubles the circuit loading. Other logic analyzers and probe sets accommodate the demultiplexing of signals, however. They allow you to attach only a single probe to each signal line; demultiplexing is performed either in the probe pod or in the logic analyzer.

A logic analyzer's sequential-triggering capabilities can help you track down problems that depend on the flow of a program. Sequential triggering can, for instance, show you what data is written to memory address FA00 by a subroutine called Meltdown. Your

Text continued on pg 60

TABLE 1—REPRESENTATIVE LOGIC ANALYZERS

MANUFACTURER AND MODEL	MAXIMUM NUMBER OF CHANNELS	MAXIMUM ASYNCHRONOUS SAMPLE RATE (MHz)	MAXIMUM SYNCHRONOUS SAMPLE RATE (MHz)	TRANSITIONAL TIMING	MEMORY DEPTH (BITS/CHANNEL)	MINIMUM GLITCH-DETECTION WIDTH (nSEC)	SYNCHRONOUS DATA-SETUP/DATA-HOLD TIMES (nSEC)	LEVELS OF TRIGGERING
ARIUM								
ML4100C SYS8	32	100	25		1k	5	5/1	13
ARRAY ANALYSIS								
MFI 1000C	62	200	25		1k	5	2/2	14
BITWISE								
L10032000	32	100	25		256	—	2/0	1
DOLCH								
LA 432	32	100	15		1k	—	2/2	8
C100	32	100	25		1k	7	8/2	4
EL TORO SYSTEMS								
PC-52	24	100	25		1k	—	4/0	1
GOULD								
K115	72	200	70		1k	5	4/0	8
K450B	80	200	50		2k	5	6/0	16
K500D	8	500	130		2k	2	2.5/0	2
HEWLETT-PACKARD								
1651A	32	100	25	•	1k	5	10/0	8
1650A	80	100	25	•	1k	5	10/0	8
16500A	400	1000	25	•	1k	5	10/0	8
HILEVEL								
3750	256	50	50		16k	—	15/0	16
IWATSU								
4620	95	200	10		1k	3	50/0	4
KONTRON								
PLA 286	96	500	20		4k	—	20/0	14
NCI								
PA 480	48	25	25		4k	—	—	16
NICOLET								
8000	64	200	25		1k	3	20/0	8
NORTHWEST INSTRUMENTS								
μANALYST 2000	80	100	20	•	4k	5	25/0	15
OUTLOOK								
T100	32	2000	250		4k	1.5	0.5/0	1
PANASONIC								
VP3663P	48	100	20		1k	5	20/0	4
PHILIPS								
PM3570	115	400	50	•	1k	4	12/0	7
RACAL-DANA								
205-08	48	10	12		250	—	30/0	4
RAPID SYSTEMS								
R3020	32	20	10		500	10	35/0	6
ROHDE & SCHWARZ								
LAS	72	400	20		1k	—	20/0	8
SPECTOR								
2330	64	400	100		512	3	2/2	8
TEKTRONIX								
1220	32	100	25		2k	—	20/0	12
1240	72	100	50		512	6	12/0	14
DAS 9200	540	2000	200		4k	1.5	2.5/0	4

THRESHOLD LEVELS	PROBE LOADING Ω, pF	MODULAR DESIGN	IBM PC REQUIRED	DSO OPTION AVAILABLE	PATTERN-GENERATOR OPTION AVAILABLE	NUMBER OF CHANNELS	TYPICAL CONFIGURATION AND PRICE		
							NO OF CHANNELS AT MAX ASYNCHRONOUS SAMPLE RATE (MHz)	NO OF CHANNELS AT MAX SYNCHRONOUS SAMPLE RATE (MHz)	PRICE
−9 TO +9V	100k, 6					32	4 AT 100	16 AT 25	$3685
TTL, ECL	100k, 5	•	•	•	•	32	16 AT 50	32 AT 25	$4475
TTL	1M, 10	•	•	•		32	4 AT 100	32 AT 25	$2295
TTL	LSTTL		•			32	4 AT 100	32 AT 15	$1995
−9.9 TO +9.9V	1M, 7		•			32	8 AT 100	32 AT 25	$7485
−6 TO +10V	12k		•			24	6 AT 100	24 AT 25	$1299
−9.9 TO +9.9V	1M, 6	•			•	72	4 AT 200	64 AT 20	$10,990
−10 TO +10V	1M, 6	•			•	80	40 AT 200	80 AT 50	$28,990
−6.35 TO +6.35V	25k, 3			•	•	8	8 AT 500	8 AT 130	$18,500
−9.9 TO +9.9V	100k, 8					32	32 AT 100	32 AT 25	$4780
−9.9 TO +9.9V	100k, 8					80	80 AT 100	80 AT 25	$8680
−9.9 TO +9.9V	100k, 8	•		•	•	80	80 AT 100	80 AT 25	$13,280
TTL, ECL	TTL	•	•		•	192	192 AT 50	192 AT 50	$14,520
−5 TO +5V	1M, 5					95	8 AT 200	64 AT 10	$11,990
−5 TO +12.5V	1M, 5	•		•	•	56	8 AT 100	48 AT 20	$10,150
TTL	—		•			48	48 AT 25	48 AT 25	$2090
−6 TO +6V	100k, 10			•		64	16 AT 200	48 AT 25	$14,650
−6 TO +6V	1M, 10	•	•		•	48	16 AT 100	32 AT 10	$9330
TTL, ECL	50k,1		•		•	32	4 AT 2000	32 AT 250	$32,500
−6.35 TO +6.35V	1M, 8					48	16 AT 100	48 AT 20	$10,925
−3 TO +12V	4M, 6	•				35	35 AT 20	35 AT 20	$7500
VARIABLE	60k, 12				•	48	48 AT 10	48 AT 12	$8055
TTL, CMOS	—	•	•	•	•	32	16 AT 20	32 AT 10	$3495
−9.9 TO +9.9V	1M, 6	•		•	•	56	8 AT 100	48 AT 20	$17,730
−6.3 TO +6.3V	1M, 7.5	•				64	8 AT 400	64 AT 100	$18,370
TTL	1M, 15					32	8 AT 100	32 AT 25	$3795
−6.35 TO +6.35V	1M, 5	•				36	36 AT 50	36 AT 50	$9950
−2.5 TO +5V	10k, 1	•		•	•	90	90 AT 20	90 AT 20	$15,820

Some of the higher-performance logic analyzers allow you to compensate for channel-to-channel skew.

first If/Then condition searches for the address that identifies the start of Meltdown. After that condition has been satisfied, the next sequential level waits until it recognizes FA00, then fills the analyzer's acquisition memory with data.

Now suppose that Meltdown doesn't write to FA00 every time it is called. The first time Meltdown is called, the first condition is satisfied, and the logic analyzer drops to the second condition (that of waiting for memory address FA00). Any subroutine can now write to memory address FA00. To avoid such unwanted triggering, you could use an If/Then/Else statement to jump back to the first condition if the system executes a return from subroutine Meltdown before addressing FA00.

Some logic analyzers provide a dozen or more sequential-triggering decision levels, allowing you to set up complex flow conditions. When you're comparing analyzers, note that the capabilities of sequential triggers vary widely. It's not enough to compare just the number of levels. For example, Hilevel's 3750 allows 16 levels of triggering, and each level has four trigger-word patterns that can be combined logically. You can perform as many as 12 different actions at each trigger level.

All logic analyzers allow you to trigger on a condition, and some also allow you to disable the trace or stop acquiring data. This feature can be useful when you only want to acquire specific data. In the Meltdown example above, when the trigger condition is satisfied the analyzer captures the desired data at FA00 and then fills the remaining 1023 locations in the 1k-sample memory with unwanted information. The disable-trace capability would allow you to store the data that went into address FA00, then disable the trace and wait until the trigger condition is satisfied again, and so on. The analyzer's entire 1k-sample memory would then contain only data written to address FA00.

Another useful triggering feature that many logic analyzers offer is range recognition. To find out whether your program ever accesses an illegal area in memory, you set up the range-recognizer condition to cover the illegal address range and then trigger on addresses inside that range.

Some logic analyzers allow you to use event counters and clock counters in your trigger condition. For instance, perhaps you have a peripheral that must be serviced within 10 msec whenever it generates an interrupt. A logic analyzer with a clock counter can trigger whenever the interrupt-service interval is ex-

Pattern generator speeds development cycle

Many logic analyzers now offer optional pattern generators. Pattern generators can perform a variety of functions, such as running design-simulation vectors through a circuit to verify that its response matches the simulation. They can also facilitate the development and debugging process by operating boards outside the system they'll eventually run in.

Suppose, for example, that you have a large, bus-oriented ATE system under development. Your company may have only one or two functional systems that you can use for debugging and integrating circuit boards during the development cycle. Yet six or eight engineers may be competing for system time to debug their circuits. The usual result is that some engineers must work graveyard shifts to get time on the system. Communication suffers and so do schedules. But a logic analyzer with a pattern generator may be able to help.

You can make a test setup consisting of a backplane connector, power supplies, and a logic analyzer with a pattern generator to provide all the inputs for the circuit under test that are needed for debugging. The pattern generator provides the stimuli, which simulate the data, address, and any other digital inputs to the circuit under test that are required.

You can configure an HP 16500A to provide 204 pattern-generation channels operating at clock rates to 50 MHz and having a memory depth of 4k patterns. Tektronix's DAS 9200 can provide as many as 1008 channels at 50 MHz with an 8k-pattern depth. See **Table 1** for other logic analyzers that provide optional pattern generators.

Other companies, such as Step Engineering (Sunnyvale, CA), provide ASIC-verification systems, which are essentially high-speed, wide-channel-width combinations of a logic analyzer and a pattern generator. You can also link a computer to your logic analyzer for generating and modifying patterns. Most logic analyzers provide IEEE-488 or RS-232C interfaces as standard, some offer them as options.

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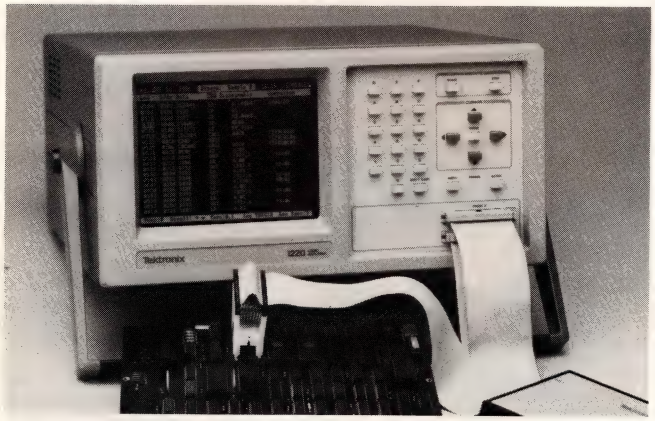
A logic analyzer can look for a glitch in an area known to be troublesome while the system runs continuously.



***32-channel, low-cost logic analyzer** (Tektronix)*

ceeded.

Unfortunately, not all logic analyzers can evaluate trigger conditions as fast as they can acquire data. If you're using an external clock running at 50 MHz, and your logic analyzer needs 35 nsec to set up and check for a new trigger condition after satisfying the previous sequential condition, you've got a problem. The logic analyzer would not be able to evaluate the new condition at the next clock cycle, so it might miss a valid trigger condition.

Logic-analyzer vendors don't always list the setup and hold time and propagation delay for their logic analyzers' triggering sections on their data sheets. The triggering section's inability to process data at high clock rates may be a problem, so be sure to ask about it.

Because logic analyzers let you set up accurate trigger conditions, you won't have to search through screen after screen of acquired data to find the information you need. Further, a logic analyzer with extensive trigger control can often get by with a smaller acquisition memory.

Memory depths vary widely

The memory depths of logic analyzers vary from 256 to 32k bits/channel. Memory depth can be important in both state and timing analysis. For example, if you've found an incorrect digital state in a system and you want to discover what caused that state, you can trigger on the incorrect state, acquiring data before the trigger (or pretriggering) so you can look for what led to the error. The longer the memory, the further back in time you can look.

Some logic analyzers, such as HP's 1650A and Philips 3570, have a feature called transitional timing, which increases the instrument's effective memory. With transitional timing, instead of storing a sample of every channel at each clock cycle, the logic analyzer stores a sample only if at least one channel has changed state. Whenever a channel changes state, the machine also stores a time value. Without transitional timing, a logic analyzer that is asynchronously clocking data in at 100 MHz will completely fill a 1k-sample memory in 10.24 μsec. With transitional timing, the analyzer will acquire data until the channels have changed state 1024 times, which may take milliseconds or even seconds, yet retain 10-nsec resolution.

If you'll be using a logic analyzer to troubleshoot a microprocessor, you need to make sure the analyzer you use provides a disassembler for that particular microprocessor. The disassembler is software that converts machine code from the microprocessor back to assembly language, which simplifies the task of following what the system is doing. Some of the higher-performance microprocessors that perform instruction prefetches (the 68000 Series processors, for example) benefit from a disassembler that can filter out instructions that were fetched but not executed. If your analyzer's disassembler doesn't provide this feature, you'll spend more time trying to sort out what the microprocessor is doing.

Time correlation suits multiprocessor work

If you'll use your analyzer to troubleshoot a dual-processor system, you'll have to consider some other analyzer features. For example, if both the processors in the system under test use different clocks, and you want to look at state information, you'll need a logic analyzer that can support the two external clocks. To compare what's happening on one processor with what's happening on the other processor at the same time, you'll also need some way to time-correlate the displayed information.

Logic analyzers that offer time correlation employ one of two general methods. One method, used in Tektronix's 1240, is to keep track of the order in which states are clocked into acquisition memory. The other method, used in Hewlett-Packard's 1650A, is time stamping: When states are clocked into the logic analyzer, a time tag is attached to every state so that you can determine not only the order in which states are clocked in, but also the actual time difference between states (**Fig 1**). Many logic analyzers can support dual-processor systems. HP's 16500A system can support as many as five independent processors, and Tektronix's DAS 9200 can support a total of six.

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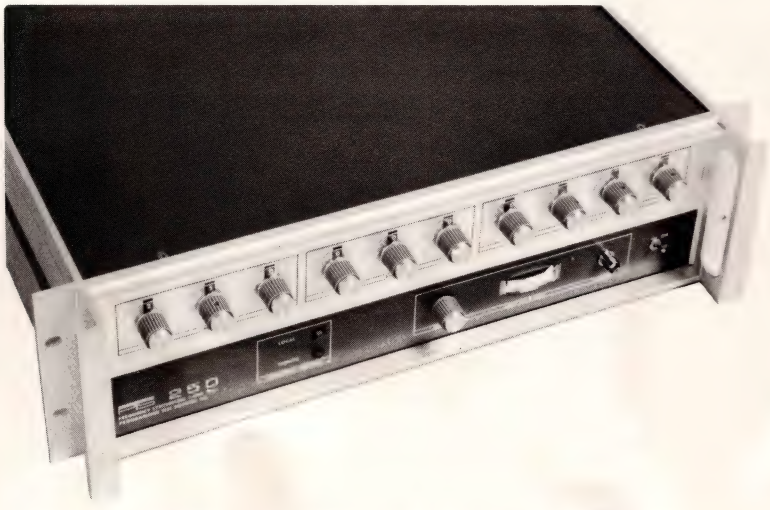

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Some logic analyzers provide a dozen or more sequential-triggering decision levels, allowing you to set up complex flow conditions.

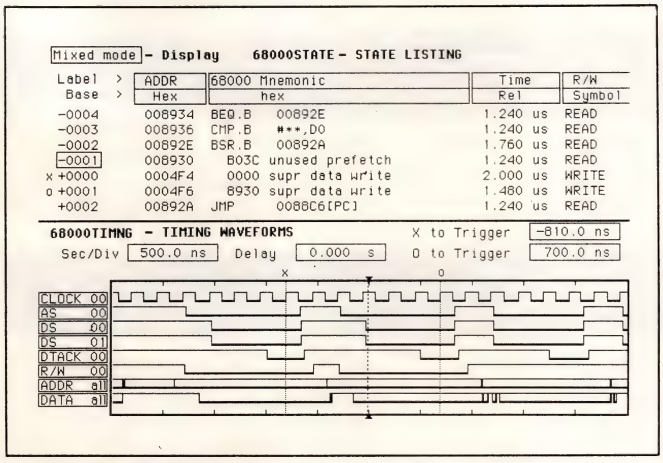

Fig 1—This printout of the 1650A's split-screen display *uses markers (x and o) to show the time correlation between the state listing and the timing waveforms. (Photo courtesy Hewlett-Packard)*

asynchronously, you'll need a logic analyzer that can support both these features at once. HP's 1650A has this capability. The 1650A can be configured as two logic analyzers, and it can also display timing diagrams and state diagrams on one display, using markers to correlate the two sets of diagrams.

Histograms help optimize system performance

For optimizing system performance, a logic analyzer that can generate and display histograms can be useful. You can set up histograms that graphically track the percentage of time your system is spending in a given part of memory. By identifying routines that are using large amounts of processor time, you can concentrate on streamlining the code in these areas.

Although most logic analyzers are stand-alone units, some require personal computers. A number of logic

For more information . . .

For more information on the logic analyzers described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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High accuracy bench DMM with extended measurement capability. It is completely portable with a built-in, ni-cad battery pack and includes true rms measurement, pulse detection, selectable dB reference level and a 4-1/2 digit LCD readout with 22-segment bar graph. Designed to meet UL 1244 requirements.

Model 460-6, 120 VAC, Cat. #12538 . . . . . **$425.00**
240 VAC, Cat. #12539 . . . . . **$425.00**

CIRCLE NO 84

NEW - Models 713 and 712 Universal Frequency Counters

Model 713 (to 520 MHz) and 712 (to 200 MHz) provide period, frequency, ratio, time interval and totalize functions for a wide range of applications from radio servicing to logic and control circuit testing and monitoring. Both feature an 8-digit, high visibility, orange LED display, selectable attenuation and self-check of the 10 MHz time base.

Model 712, 120 VAC, Cat. #12722 . . . . . **$525.00**
220 VAC, Cat. #12723 . . . . . **$525.00**
Model 713, 120 VAC, Cat. #12724 . . . . . **$675.00**
220 VAC, Cat. #12725 . . . . . **$675.00**

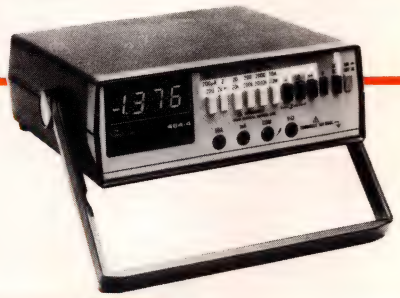
CIRCLE NO 79

NEW - Models 488 and 487 Digital Multimeters

These new handheld DMMs feature autoranging and data/peak hold, and a 3-1/2 digit LCD plus 71-segment analog display. Housed in a shock resistant case for rugged use. AC and DC current measurements; 300 μA to 20 A; 1000 VDC, 750 VAC (rms); diode check; and resistance to 30 MΩ. The Model 488 features true rms measurements.

Model 487, Cat. #48700 . . . . . **$219.00**
Model 488, Cat. #48800 . . . . . **$275.00**

CIRCLE NO 81



NEW - Model 464-4 DMM

Provides true rms voltage and current readings. Big, orange 3-1/2 digit LED display for easy reading. 100 kHz frequency response. Designed to meet UL 1244 requirements.

Model 464-4, 120 VAC, Cat. #12677 . . . . . **$325.00**
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CIRCLE NO 85

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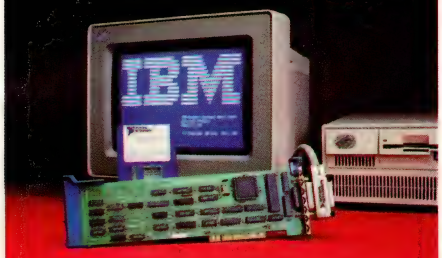

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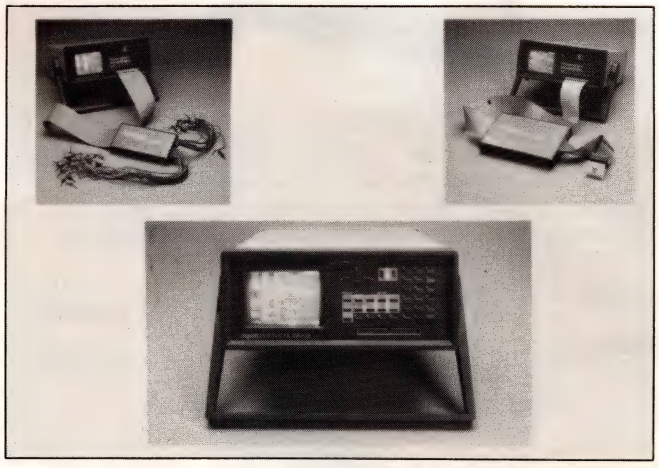


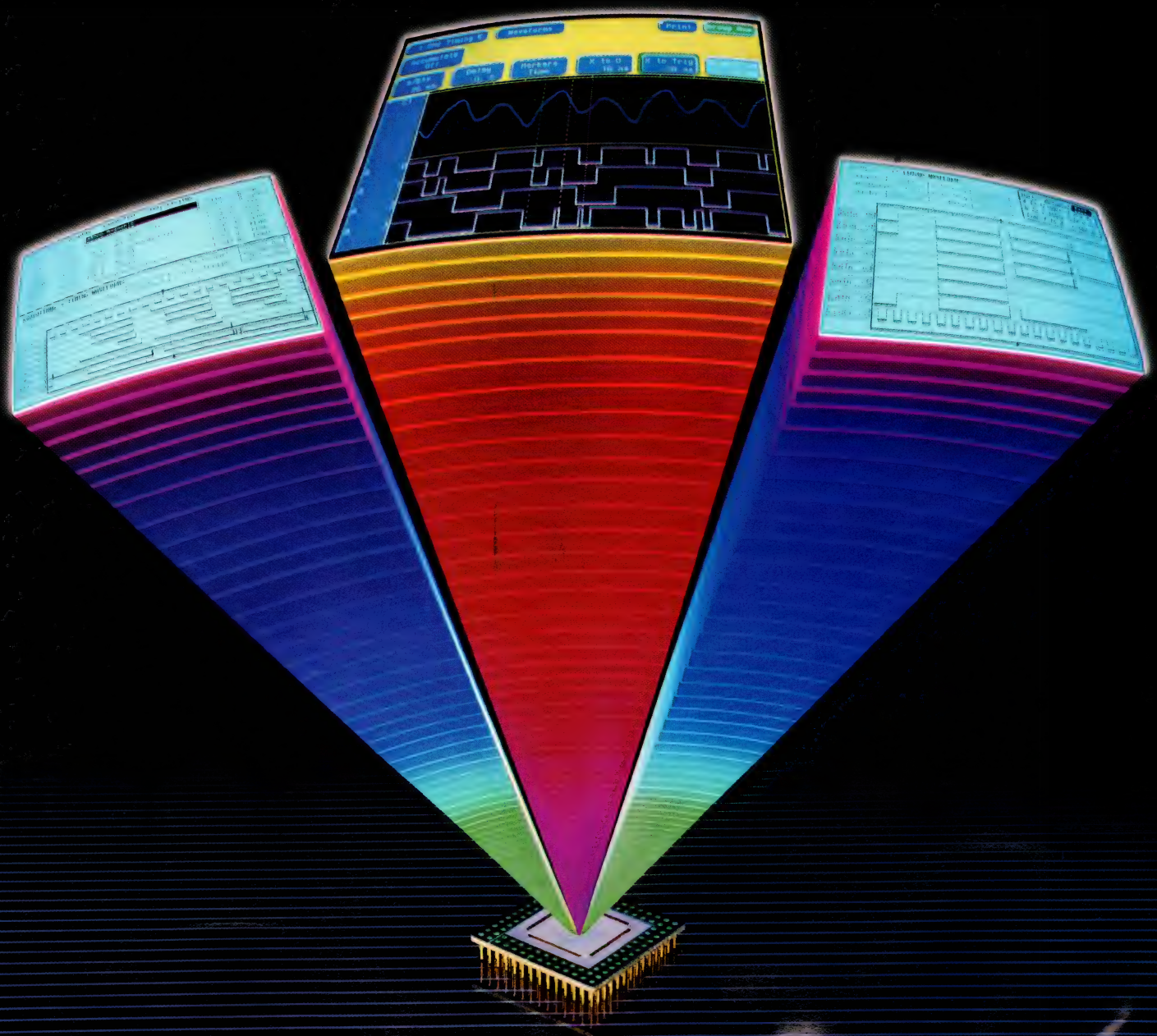
Logic analyzer that allows multiplexing of channels *(Arium)*

analyzers exist as interface boards for personal computers (primarily for the IBM PC family and compatibles). Other analyzers—such as Kontron's KSA 64 and models from Array Analysis, Hilevel, Northwest Instruments, Outlook, and Rapid Systems—are housed in a separate enclosure and use an IBM PC or compatible computer for display and control purposes. Still other analyzers are portable IBM PC/AT compatibles that the vendors have customized to operate as logic analyzers. Kontron's PLA 286, for instance, operates as a stand-alone logic analyzer when you detach the keyboard. (When the keyboard is attached, you can use it as an ordinary PC.)

Thanks to the highly competitive logic-analyzer market, manufacturers have continued to improve the performance of their logic analyzers, yet the prices of several models actually declined in the last year. In the future, you can expect such features as transitional timing, time stamping, and at least one analog input channel to become standard on all high-performance analyzers. As manufacturers continue to narrow the timing-performance gap between logic analyzers and oscilloscopes, you'll see other vendors following Outlook's lead by incorporating equivalent time sampling as a standard feature. **EDN**

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

Hewlett-Packard's new logic analyzer family offers you something not found in other logic analyzers...



HP's new logic analyzer family gives you more of what you want in logic analyzers. For less.

So now measurements are easier to make. And high-quality HP logic analyzers are easier to buy!

You get the performance that best suits you: from 32 to 400 channels of 100 MHz transitional timing/25 MHz state, and up to 80 channels of 1 GHz timing analysis.

Our new family also offers you easy operation, powerful triggering, a CAE link, an oscilloscope, pattern generation, portability, built-in mass storage, simple probing, optional 3-year protection, and much more.

The small secret behind the big value.

To give you more for your money, HP developed a Logic-Analyzer-on-a-Chip containing a complete state analyzer, timing analyzer, and acquisition memory. This proprietary HP IC makes exceptional value possible...80 channels of 100 MHz transitional timing for only $7,800*.

You can assign state or timing in 16-channel increments. Get fully independent state, timing, state/timing, or state/state setups. Even time-correlate measurements on complex multiprocessor systems.

Operational simplicity runs in the family.

We've made our controls even easier than before, without sacrificing performance.

You can make timing or state measurements using just three menus, so you never get lost. Triggering setups, from the simple to the complex, are a snap. And autoscale gives you one-button setup for timing analysis.

You even get a color touch-screen and knob, or optional mouse with the new HP 16500A. Color lets you quickly distinguish between menu choices, measurements, and results...and find glitches more easily.

Probing made easy.

HP's new passive probes are lightweight and flexible...specially designed to grip easily and securely to your device under test. Plus, our preprocessors give you quick setups with most popular 8, 16, and 32-bit μPs, including the Motorola 68020 and Intel 80386. And if you've already invested in HP preprocessors, we offer you an easy upgrade path.

HP 1651A: full-featured logic analyzer for only $3,900.*

With 32 channels of 100 MHz transitional timing for just $3,900*, the HP 1651A gives the hardware engineer a highly economical, yet powerful debugging tool.

It's a full-featured logic analyzer with no compromises in state and timing capabilities (25 MHz state/100 MHz transitional timing on all channels), memory depth, triggering, or I/O features. It supports most popular 8-bit μPs with full inverse assembly. Plus it's compact, weighs just 22 lbs., and has an optional carrying case for easy transport.

HP 1650A: the new standard in general-purpose logic analysis for just $7,800.*

The HP 1650A features time-correlated state/state or timing/state operation on 80 channels. Plus eight sequence levels to meet your toughest triggering tasks. Yet it's priced below $8,000!

You get 25 MHz state/100 MHz transitional timing on all 80 channels, and preprocessor support for 8, 16, and 32-bit μPs. And, the

More value.

HP 1650A is portable, lightweight, and small enough to fit comfortably on a crowded workbench. It's also programmable, has a built-in disc drive for storing measurements, and provides hardcopy documentation.

through your choice of performance modules. You can have up to 400 channels of 25 MHz state/100 MHz transitional timing. 8 channels of full-featured, simultaneous scope analysis. 80 channels of 1 GHz timing. Or 204 channels of 50 Mbit/sec stimulus.

Just $12,400* buys you a basic configuration with 80 channels of 25 MHz state/100 MHz transitional timing.

You can trigger one module with another. Time-correlate measurements between modules...400 Ms/sec scope and 1 GHz timing, for example. Even view state, timing, and analog on the same screen! Fully programmable, the HP 16500A eliminates the need for separate data storage and printer control. HP-IB and RS-232 are standard.

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The HP 16500A is part of HP DesignCenter...a product development environment that unites engineers from IC design/verification to PCB design and test. By linking the HP 16500A with HP CAE, you can compare measurement results and simulated data on your workstation, and use measurement results as your simulator patterns.

HP 16500A: modular system solution, priced your way.

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HP 1651A $3,900*

The HP 1651A is a general-purpose, low-cost 32 channel logic analyzer with many features normally found on more expensive analyzers.

- 100 MHz transitional timing on all 32 channels.
- 25 MHz state on all channels.
- Support for most popular 8-bit μPs.
- Fully programmable, with built-in disc drive and hardcopy output.
- Portable and compact — weighs just 22 lbs.
- Optional 3-year protection.

HP 1650A $7,800*

The HP 1650A is a general-purpose logic analyzer with a range of features to satisfy many requirements in design and test.

- 100 MHz transitional timing/25 MHz state on all 80 channels.
- Support for most popular 8, 16, and 32-bit μPs.
- Configurable as 2 totally independent analyzers.
- Fully programmable, with built-in disc drive and hardcopy output.
- Eight sequence levels with storage qualification, pattern and range recognizers.
- Glitch capture on all channels.
- Optional 3-year protection.

HP 16500A

The HP 16500A is a modular, configurable system solution that can meet a wide variety of logic analysis, oscilloscope, and stimulus-response measurement requirements.

- Configurable through your choice of performance modules:
  - 25 MHz state/100 MHz transitional timing (80 channels per module) $5,200*
  - 400 Ms/sec 100 MHz bandwidth digitizing oscilloscope (2 channels per module) $5,500*
  - 1 GHz timing (16 channel master) $7,800*
  - 50 Mbits/sec pattern generation (12/48 channels per module) $3,700/$4,000*
  - Mainframe $7,200*
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8½-digit DMM self-calibrates by using independent internal reference

The Model 1281 digital multimeter provides unusually stable readings of dc and ac voltage, resistance, and (optionally) dc and ac current. When measuring dc voltage, the 3½-in.-high unit maintains an average temperature coefficient of >0.25 ppm of full-scale range(FSR)/°C from 13 to 33°C. Its dual internal zener references exhibit an average temperature coefficient of 0.1 ppm/°C from 0 to 50°C and are guaranteed to drift no more than 3 ppm/year at 23°C. As part of the manufacturing process, the vendor monitors the stability of each reference for 90 days.

One of the references functions as the working standard. The other, in conjunction with an internal microprocessor, nonvolatile memory, solid-state choppers, and a precision

transformer, enables the instrument to perform self-calibration, which does not depend on resistance ratios.

The stability of ac and ohm measurements is consistent with the unit's dc-voltage performance. For example, despite ambient-temperature variation from 18 to 28°C for one year after calibration with external equipment, the ac-voltage measurements are accurate to 80 ppm of reading+10 ppm of FSR from 40 Hz to 10 kHz, and the resistance measurements are accurate to 8 ppm of reading+0.3 ppm of FSR. You can control the instrument via an IEEE-488.2 interface. The basic instrument costs $5700; if you order it with optional true rms-measurement capability and 2- and 4-wire resistance capability, it costs $7950. Delivery, 10 weeks ARO.

Datron Instruments Inc, Box 85434, San Diego, CA 92138. Phone (619) 450-9971. TLX 756953.

Circle No 722

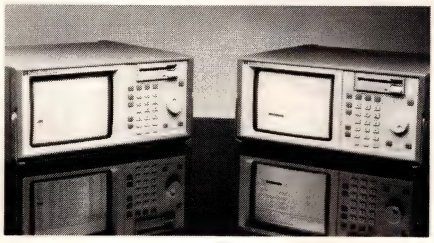
Datron Instruments Ltd, Hurricane Way, Norwich Airport, Norwich NR6 6JB England. Phone (0603) 404824. TLX 975173.

Circle No 723

$3900 32-channel logic analyzer samples data at 100 MHz

The HP 1651A 32-channel logic analyzer can sample data at 100 MHz. It performs transitional timing and state analysis and can perform both types of analysis simultaneously. As a state analyzer, it stores 1024 samples/channel and works with systems having single-phase clocks whose frequency is as high as 25 MHz and whose pulse width is at least 10 nsec. The unit includes two state analyzers and has a pair of clock inputs. You can use either clock with either analyzer, and you can logically OR the clocks or operate the state analyzers in demultiplexed or 2-phase mixed modes.

The instrument has eight pattern recognizers. When only one state analyzer is active, you can trigger on all eight. When both state ana-



lyzers are active, you can use four pattern recognizers with each state analyzer. An 8-level state machine allows you to specify pattern sequences, which must appear before triggering occurs.

The unit accepts input signals from −9.9 to +9.9V with a min p-p swing of 600 mV. You can set the threshold in 0.1V steps with an accuracy of ±150 mV from −2 to +2V and an accuracy of ±300 mV elsewhere in the input range. You connect the analyzer to the unit under test via passive probes at the end of 16-channel flat-woven cables. You can use the instrument to detect glitches as short as 5 nsec. In glitch-capture mode, it stores information about both data and glitches at every sample period.

Though the unit has no IEEE-488 interface, its integral 3½-in. floppy-disk drive allows you to store and recall instrument setups and measurement results. You can connect a printer to an RS-232C port and print out the current screen display. $3900; pods and decompilers for popular 8-bit μPs, $880 to $1110.

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Circle No 724

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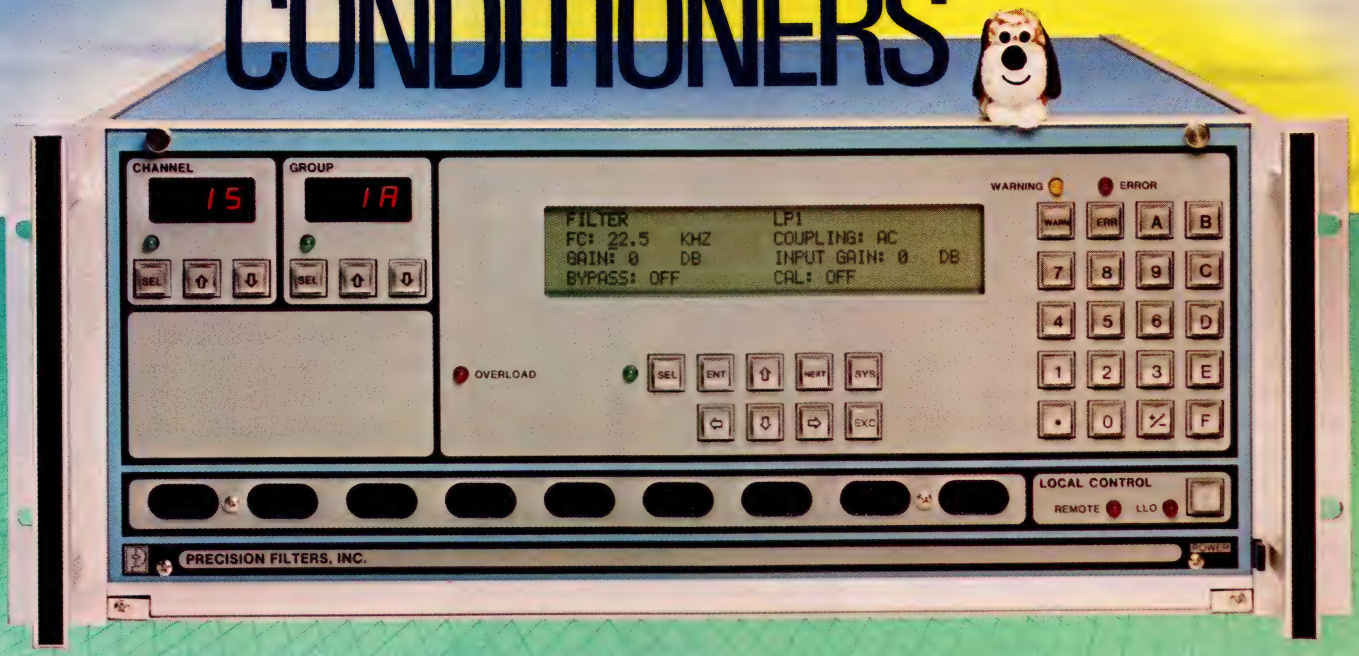

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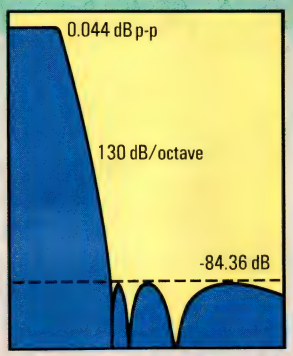

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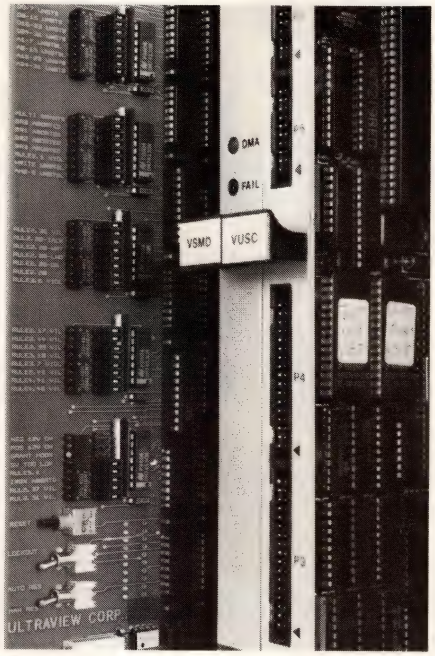
CIRCLE NO 75

Debugging tool triggers on VME Bus anomalies

When you plug the VBAT VME Bus-anomaly trigger board into an unused slot in a VME Bus-based system, it can monitor all activity on the bus. Within 80 nsec after it detects any of a large number of common VME Bus timing-protocol violations, it lights an LED and provides a trigger output. You can use the unit in conjunction with a logic analyzer to learn the basis of problems such as incompatibility among boards from several vendors or latent timing violations in products you are developing. The VBAT's 104 separate triggering circuits continuously and simultaneously monitor 94 bus lines. Its rule-based triggering algorithms detect 26 classes of timing-protocol violations and provide trigger coverage that's broader by two orders of magnitude than that provided by the pair of ORed parallel triggers found on many logic analyzers.



Among the conditions that the unit detects are address, data, and write lines changing when they should be stable; $\overline{DS0}$ or $\overline{DS1}$ asserted before the bus is granted (or rescinded before $\overline{DTACK}$ goes high, and new bus grant generated before $\overline{BBSY}$ is rescinded.

When you attempt to use a logic analyzer by itself to detect timing problems on a complex bus such as the VME Bus, you must often use trial and error to devise a triggering strategy likely to reveal the problem. The VBAT's parallel-triggering approach quickly establishes a trigger that you can apply to a logic analyzer. With some repetitive timing violations, the trigger occurs rapidly enough so that you can use it to obtain readable displays with nonstorage oscilloscopes. $1495.

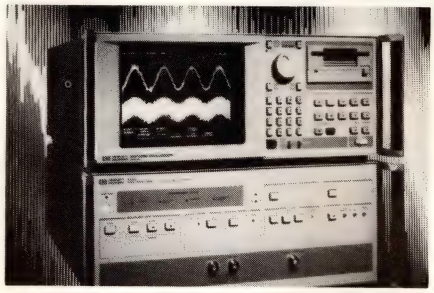
Ultraview Corp, Box 14734, Fremont, CA 94539. Phone (415) 657-9501.

Circle No 725

Waveform recorder makes 250M 8-bit conversions/sec

The HP 5185A waveform recorder and the HP 5185T precision digitizing oscilloscope, which includes the waveform recorder, contain a pair of 8-bit flash ADCs that makes 250 million conversions/sec. The units offer an input bandwidth of 125 MHz, have maximum sensitivity of ±50 mV full scale (400 μV/LSB) and provide memory that's 64k samples deep. The recorder is intended for applications in which a separate computer, such as the vendor's Vectra PC, provides system control and data analysis. In addition to its 2048×2048-point monochrome display, the precision scope has the ability to perform 20 types of calculation and analysis on acquired data.

The scope can calculate and display FFTs; voltage, power, and phase spectra; p-p and rms voltages; frequency of sinusoids; and energy in a waveform. Included in the scope's repertoire is a waveform-reconstruction algorithm called X-Fill that can improve the time-domain analysis of captured data as though the data had been sampled at 4× the actual sampling rate (as long as sampling took place at >2× the highest frequency component present in the data). In other words, X-Fill can make data sampled at 2.5× the Nyquist frequency look as though it had been sampled at 10× the Nyquist frequency. To further aid in time-domain analysis, the scope has a zoom feature that lets you magnify small portions of a waveform and pretrigger memory stores to as many as 64k samples that occurred prior to the trigger. Waveform recorder, $28,200; oscilloscope, $40,000. Delivery, eight weeks ARO.



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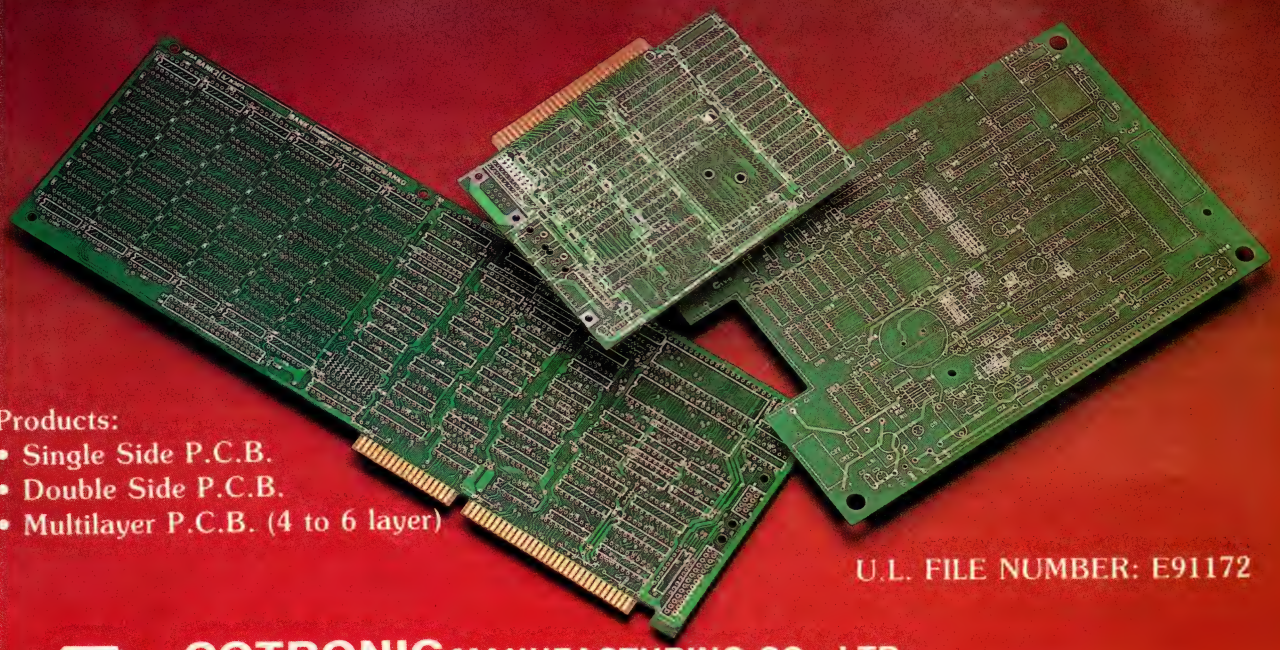

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CIRCLE NO 11

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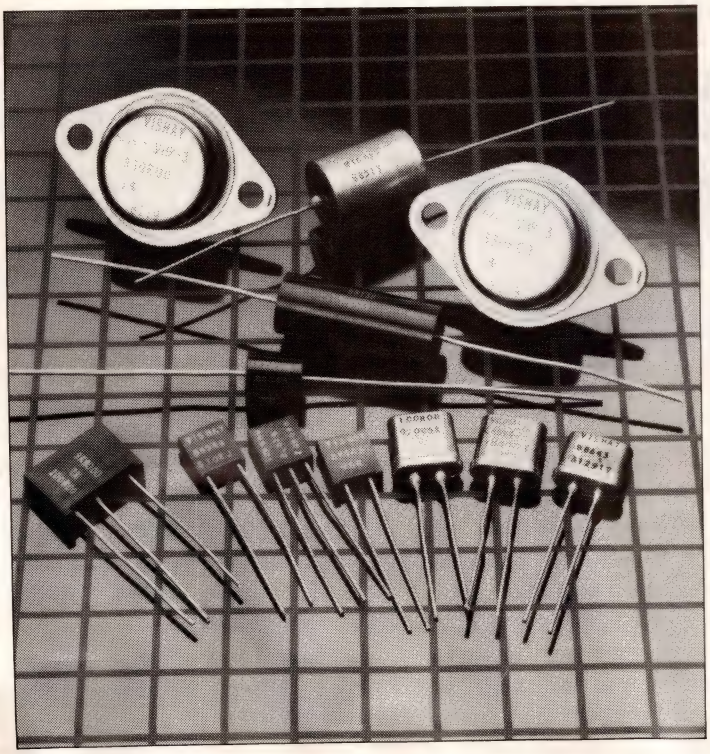

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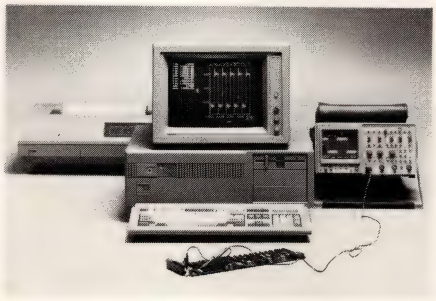
CIRCLE NO 36

IEEE-488 instrument controller uses 80386 and 80387 processors

The PEP 301 is an MS-DOS-based hardware and software system for controlling instruments via the IEEE-488 bus. Its system unit uses an 80386 μP operating at a clock speed of 16 MHz with no wait states, accompanied by an 80387 arithmetic coprocessor and 1M byte of RAM. You can configure RAM above 640k bytes either as a RAM disk or as expanded memory, in accordance with the EMS (extended-memory specification) standard. The system's high-resolution color monitor can display graphics compatible with the IBM CGA and EGA standards; the video adapter board supports both standards.



The mother board has eight I/O card slots—five 16-bit slots, two 8-bit slots, and one proprietary 32-bit slot. As shipped, the 32-bit slot is open, and you can locate the I/O cards so that three 16-bit slots are open. The system includes a 40M-byte hard-disk drive and a 1.2M-byte, 5¼-in. floppy-disk drive; you can add one full-height or two half-height storage devices.

The system includes the vendor's Guru II (GPIB user-resource utility) software, MS-DOS, and GW-Basic; it also runs several MS-DOS-based software packages available from the vendor. Some of the packages allow individuals with no previous programming experience to develop IEEE-488 instrument-control programs that run on the system. The system is compatible with popular third-party software, including 1-2-3, Framework, Timeline, and all Microsoft MS-DOS products. The product's price includes installation and system integration as well as a 1-year warranty. $7995. Compatible software, $500 to $2095.

Tektronix Inc, Instruments Group Inquiry Dept, Box 1700, Beaverton, OR 97077. Phone (800) 833-9433, ext 170; in OR, (503) 627-9000. TLX 151754.

Circle No 726

Function generator delivers arbitrary waveforms at 5 nsec/point

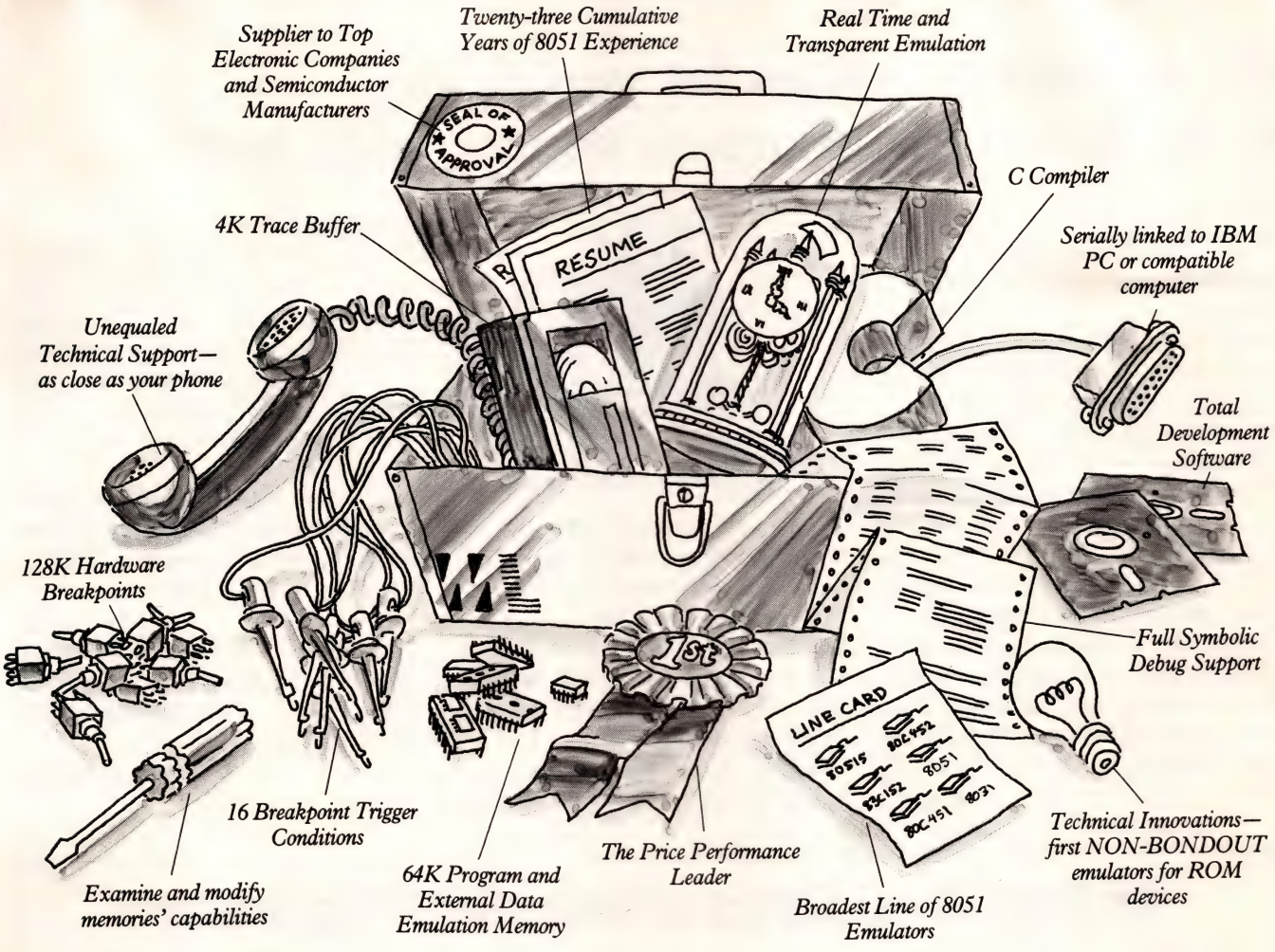
The Model 9100 is a dual-channel instrument intended for benchtop or ATE (automatic test equipment) applications requiring both standard and user-defined waveforms at high data rates. It can produce square waves at frequencies as high as 100 MHz, sine waves at frequencies as high as 25 MHz, positive- or negative-going pulses with durations as short as 5 nsec, ramps, triangular waves, and dc levels. Its accuracy is ±1% (or ±20 mV) from −10 to +10V into a high-impedance load, or −5 to +5V into a 50-Ω load. The full-amplitude rise time is ≤5 nsec with <±3% aberrations.

As an arbitrary-function generator, the instrument can produce waveforms containing from four to 65,536 8-bit points at rates ranging from 5 nsec to 20 sec/point. You can assign all the points to one waveform; when the unit produces two waveforms, you can assign 32,768 points to each waveform. The unit can store multiple waveforms comprising 350k points in its battery-backed RAM for two months with the power off. You can link multiple waveforms and generate composite waveforms continuously or for a limited number of repetitions (you can specify as many as 65,536 repetitions).

The vendor provides an optional waveform-generation software package, Easywave, which runs on IBM PCs, PC/XTs, PC/ATs, and certain compatible computers. It allows you to define waveforms by using equations, by selecting and combining standard waveform elements, or by editing acquired waveforms. You can control the generator via a standard IEEE-488 port or an RS-232C port. $8900; detachable handheld control panel, $700. Easywave software, $1300. Delivery, eight weeks ARO.

LeCroy Corp, 700 S Main St, Spring Valley, NY 10977. Phone (914) 425-2000.

Circle No 727



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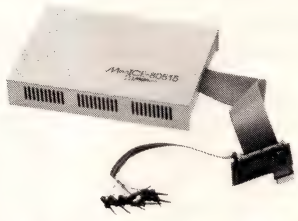
MetaICE-8044	

FOR FREE 8051 FAMILY POCKET REFERENCE GUIDE: CIRCLE NO 89



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CIRCLE NO 77

PC-based emulators let you debug C or Pascal programs at source-code level

When you use them with the appropriate Pascal or C compiler, the KSE4 Series emulators let you debug software for 16-bit 8086- and 68000-family μPs at the Pascal or C source-code level, as well as at the assembly-code level. You can control the emulators from the company's KDS-286 workstation, or from an IBM PC/AT or compatible computer, via an RS-232C or IEEE-488 interface.

For high-level-language debugging, the emulators allow you to display the source code, the static and automatic variables, the hierarchy of function calls, and the parameters passed between functions, in user-definable screen windows. To examine machine-code operation,

you can set up windows to display processor registers, memory contents, and trace-analyzer data. All the screens are dynamically updated as you step through the program, and you can switch between assembly-level and high-level-language debugging at will.

The emulators provide four hardware breakpoints that you can logically combine; you can define them by using unique addresses, address ranges, data, and target-processor control-line conditions. The emulators can accommodate as much as 2M bytes of emulation memory and a 64-channel, 8k-word trace analyzer. From approximately DM 12,000 to DM 40,000.

Kontron Messtechnik GmbH, Oskar-von-Miller-Strasse 1, 8057 Eching, West Germany. Phone (08165) 770. TLX 526719.

Circle No 729

Kontron Electronics Inc, 630 Clyde Ave, Mountain View, CA 94039. Phone (415) 965-7020. TWX 910-378-5207.

Circle No 730

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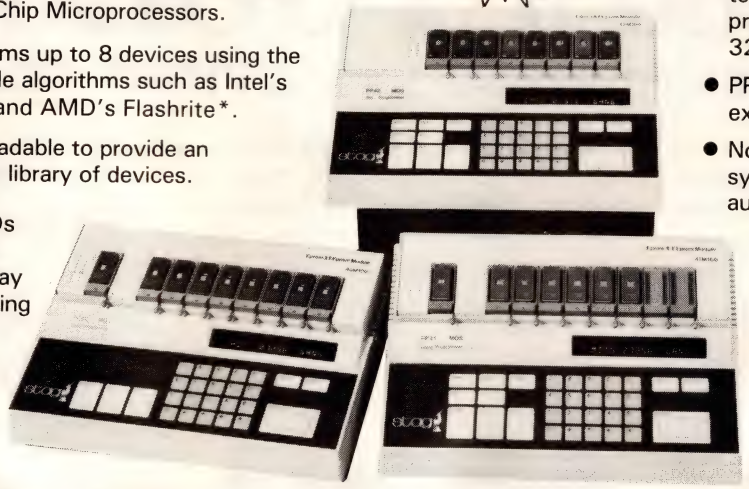

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For further details, contact:

Stag Microsystems Inc.
1600 Wyatt Drive
Santa Clara, CA 95054
(408) 988-1118 (CA)
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Amherst, N.H. 03031
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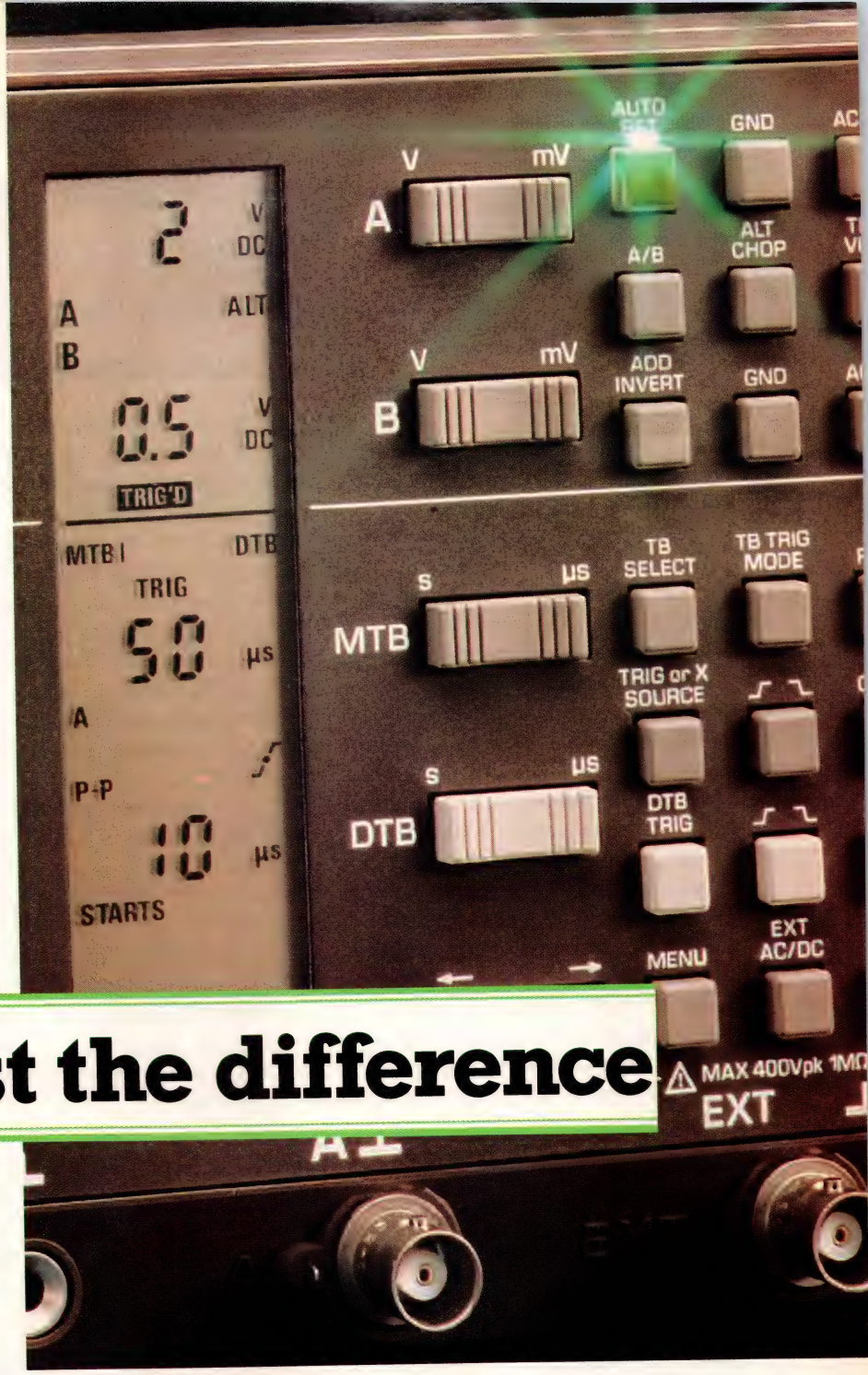

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TIMER/COUNTER

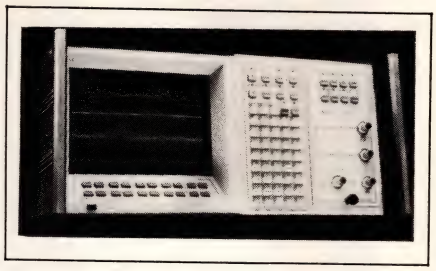
The PM 6666 programmable timer/counter covers frequencies from dc to 120 MHz at 1-Hz resolution and can optionally handle 1.1-GHz signals. The unit uses reciprocal counting with an internal μC to eliminate the ±1-cycle errors normally associated with this technique. With a 1-sec measuring time, the resolution is seven digits. To make time measurements, you can invoke an average mode that permits you to measure intervals with a resolution of 20 psec. Optional mathematical compensation of the crystal's temperature coefficient produces stability of 2×10^{-7} over the 0 to 50°C range. Instead of equipping the counters with a proportional oven, the factory measures each crystal's frequency-vs-temperature characteristic and stores corrections in nonvolatile memory. You can select trigger levels from −50 to +50V, display the trigger levels, and autotrigger at frequencies higher than 100 Hz. You can remotely program 20 functions using an optional IEEE-488 interface. $995.

John Fluke Mfg Co, Box C9090, Everett, WA 98206. Phone (800) 426-0361; in WA, (206) 347-6100. TWX 910-445-2943.

Circle No 358

WAVE ANALYZER

The vendor has added Zoom CZT (Chirp Z transform) capability to the firmware of the Data 6100 Universal Waveform Analyzer. At a fixed sampling rate and with a number of data points, CZT analysis provides a 65-fold improvement in frequency-domain resolution compared with FFT analysis, which the unit also provides. However, the improvement in resolution comes at the cost of roughly tripled computation time. Another benefit of the new firmware is that it allows you to select as many as 30,000 waveform samples; the system does not restrict the number of samples to powers of two. You can also define the center frequency and the display's window width. You can make the frequency window very narrow or widen it to four times the sampling frequency.



Available plug-ins provide as many as four channels with 14-bit resolution at 100k samples/sec (kHz); 16 bits at 1 MHz; 12 bits at 36 MHz; 8 bits at 100 MHz; and, for repetitive waveforms, 16 bits at the equivalent of 100 GHz. You can store setups, programs, and data in 48k bytes of nonvolatile RAM. $7995; plug-ins (one required), $2495 to $12,800.

Analogic Corp, Data Precision Div, Electronics Ave, Danvers, MA 01923. Phone (800) 343-8150; (617) 246-1600. TLX 6817144.

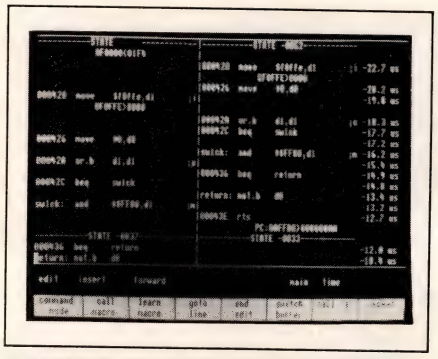
Circle No 359

SYNTHESIZER

The FS-2000-18 synthesizes 10-MHz to 18-GHz frequencies with 4-Hz resolution (0.4 Hz optional); it switches frequencies in less than 1 μsec. At 100 MHz with a 10-Hz offset from the carrier, the absolute phase noise—including internal reference noise—is −105 dBc/Hz (105 dB below carrier level/Hz). At 20 kHz from the carrier, noise drops to −150 dBc/Hz, and when the carrier is programmed to 18.4 GHz, the equivalent spec is −108 dBc/Hz. Spurious signals are −70 dBc to 2.3 GHz; −64 dBc to 4 GHz; −58 dBc to 9.2 GHz; and −52 dBc to 18.2 GHz. The harmonics are −25 dBc max. The unit has a parallel BCD interface; you can get an IEEE-488 interface with a "fast learn" mode as an option. $89,500. Delivery, 20 weeks ARO.

Comstron Corp, 10 Hub Dr, Melville, NY 11747. Phone (516) 756-1100. TLX 4973525.

Circle No 360



DEVELOPMENT SYSTEM

The Echo μP-development system can now list on screen the time-aligned traces of software that executes on two different μPs. If you are developing multiprocessor systems, this feature lets you correlate the order in which two μPs execute instructions and determine the time they require for instruction execution. Using the capability, you can mix state display and assembly and high-level-language tracing in any combination. The system includes a 20M-byte hard disk; a 1.2M-byte floppy-disk drive; 1M byte of main memory that's expandable to 4M bytes; and a 9-in. CRT. It also includes one processor-specific personality card with 64k bytes of overlay memory for 8-bit chips and 256k bytes to 1M byte of overlay memory for 16-bit chips; one emulation pod; complete emulation software; and an assembler, a linker, and a loader. Among the options are pods for simultaneous emulation of as many as eight μPs. Eight-bit μPs, $8940; 16-bit μPs, $12,980.

Arium Corp, 1931 Wright Circle, Anaheim, CA 92806. Phone (800) 862-7486; in CA, (714) 978-9531.

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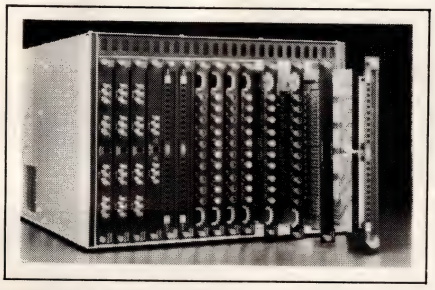
CIRCLE NO 74

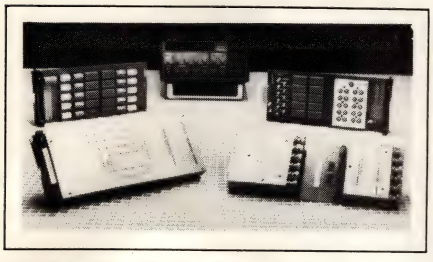


SIGNAL SWITCH

In a single 12¼-in.-high, rack-mountable chassis, Series 1251 switching modules can provide as many as 280 channels of microwave, RF, audio, video, high-voltage and high-current signal switching that's programmable via an IEEE-488 interface. Plug-in cards allow you to configure the units to handle frequencies as high as 26.5 GHz, voltages as high as 250V ac, and currents as large as 8A. You can interconnect eight chassis to increase the capacity to 2240 channels. The internal analog bus has 10 lines; in a single 14-slot chassis, some of the configurations you can create with the bus are a 4×70 matrix and a 280×1 multiplexer. The typical measured noise is ≤−120 dBm in a 5-kHz bandwidth. Typical system with 14 modules, $9950.

Racal-Dana Instruments Inc, 4 Goodyear St, Irvine, CA 92718. Phone (714) 859-8999. TLX 678341.

Circle No 363



SCANNER CARDS

The 7158 low-current scanner, 7168 nanovolt scanner, 7067 4-wire resistance scanner, and 7402 thermocouple scanner are plug-in cards compatible with both of the vendor's scanner mainframes. The low-current scanner offers 10 channels of 1-pA switching and is designed for use with relatively inexpensive coaxial cables. It switches in 1 msec, tolerates common-mode voltages of 30V, and is configured so that you can connect the output of several scanner cards to a single measuring instrument.

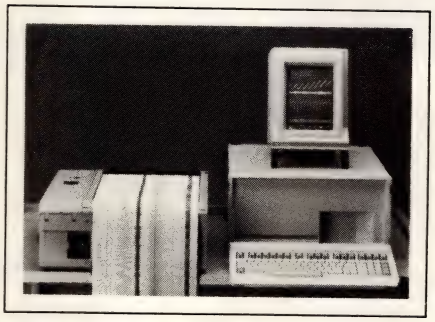
The nanovolt scanner has eight 2-pole channels implemented with junction-FET switches, and it achieves a differential offset of 20 nV. Copper-to-copper connections minimize thermocouple EMFs. Its actuation time is less than 3 msec, and at room temperature its input leakage is less than 50 pA.

The 10-channel resistance scanner offers both current sourcing and low-voltage sensing. Its 4-wire configuration minimizes the effect of IR drops in the measurement setup. The scanner provides a pair of source contacts capable of switching 350 mA and a pair of low-voltage contacts with 1-μV offset.

The thermocouple scanner is a 9-channel, 2-pole unit with integral cold-junction compensation. You connect thermocouples to it via an electrically isolated isothermal block; a semiconductor sensor monitors the block's temperature. 7158, $950; 7168, $1995; 7067, $630; 7402, $500.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469.

Circle No 362



RECORDER

The ES2000 system monitors as many as 40 analog or 80 digital signals. It consists of a data-acquisition and control unit based on a 68000 μP, an electrostatic printer with a stationary array of 2112 writing elements, a nonfade monitor scope, and a keyboard. It records analog signals at frequencies as high as 35 kHz and transients as short as 25 μsec at chart speeds from 0.25 to 500 mm/sec. You can program all functions via IEEE-488, RS-232C, and RS-422A interfaces. You can store an unlimited number of system setups, each with more than 100k bytes of annotation, on disks in the integral 3½-in. floppy-disk drive. The plug-in architecture lets you configure the unit with signal conditioners appropriate to your application. Two types of signal conditioners are available: One provides a pair of balanced-to-common inputs, calibrated zero suppression, and two event channels; the other has four event channels.

The unit accepts 11-in.-wide fanfold or roll paper. It eliminates parallax by printing grid lines and time marks as it writes data; it lets you annotate printouts with chart speed, time marks, real time and date, and parameter identification. In addition, it will print out as many as 12 pages of text describing each test setup. $18,700. Delivery, 60 days ARO.

Gould Inc, Test and Measurement, 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315.

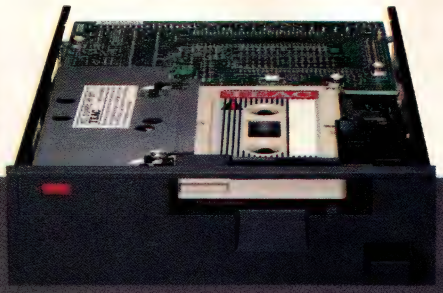
Circle No 364

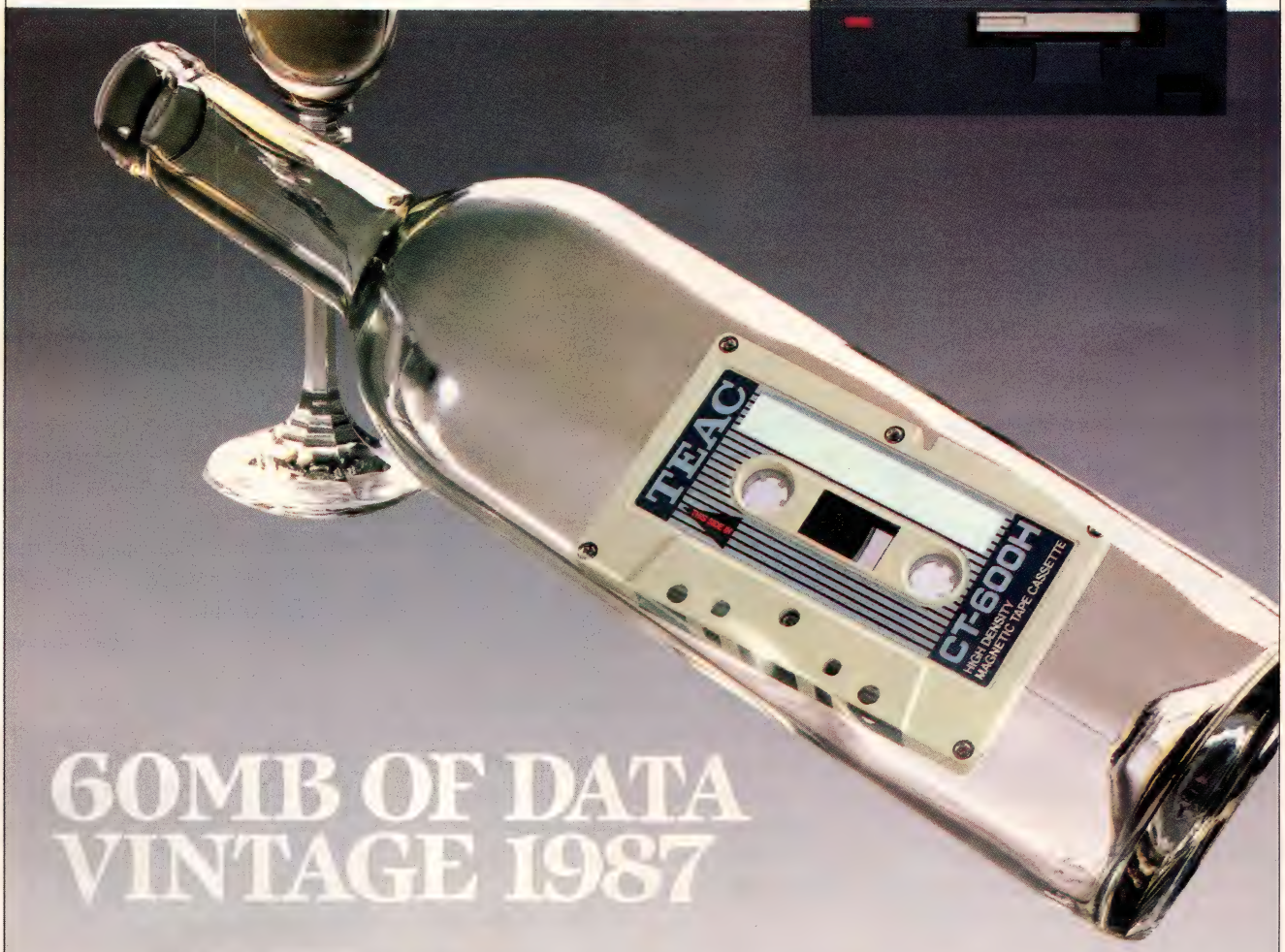
DIGITIZING SCOPE

The HP 54120T features a color display and, when in its "average display mode," can digitize four channels of repetitive input signals containing frequencies to 20 GHz. In "persistence mode," the bandwidth is 12.4 GHz max. The ADC resolves 12 bits; input impedance is 50Ω. You can set the scale factor from 1 to 80 mV/div, sweep speed from 10 psec to 1 sec/div, and trigger delay from 16 nsec to 1000 times the screen width or 10 sec, whichever is smaller. Integrated within the unit is a TDR (time-domain reflec-

MT-2ST

HALF-HEIGHT DIGITAL CASSETTE DATA STREAMERS: AN IDEA WHOSE TIME HAS COME





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tometer) system with a combined rise time (pulse generator and scope) of 45 psec. The instrument performs several computations on data it acquires when making TDR measurements: Data is converted from the time domain to the frequency domain; before conversion back to the time domain, the computed frequency-domain response passes through a normalization filter derived from short-circuit and 50Ω calibrations. $27,825.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

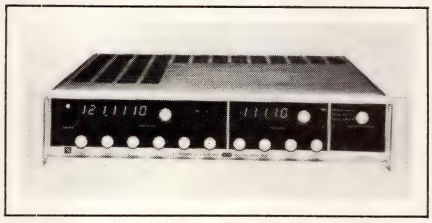
Circle No 365

EEPLD DEVELOPMENT

The Erasic Development System supports the vendor's electrically erasable PLDs. It consists of a PLD programmer, which can also program EEPROMs; an interface card for an IBM PC, PC/XT, or PC/AT; MultiMap, a PLD-design program; MultiSim, a PLD-simulation program; and more than 30 tutorial design examples. Data I/O Corp's (Redmond, WA) Abel PLD design package is available from the vendor as an option; you need it to run the PLD-design and -simulation programs. On a PC/AT, the PLD-design program creates a JEDEC-standard load file for device programming; the program creates designs that utilize as much as 90% of the gate structures within a PLD. The PLD-simulation program employs test vectors of your specification in performing a logic simulation of the device design. $749; with Abel, $1895.

Exel Microelectronics Inc, Box 49007, San Jose, CA 95161. Phone (408) 432-0500. TWX 910-338-2116.

Circle No 366

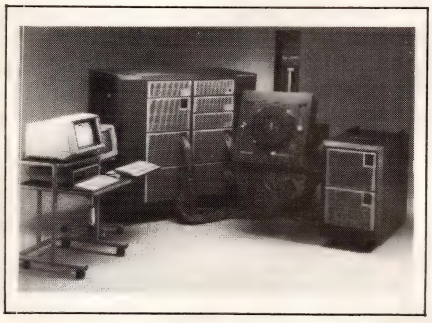


AC CALIBRATOR

The Model 4503 ac-voltage calibrator lets you control amplitude and frequency via an IEEE-488 interface. It covers the range of 30 Hz to 120 kHz with a frequency accuracy of 0.001%. You can vary the output level of the 3.5-in. rack-mountable unit from 1 mV to 120V ac in five ranges with 1-ppm (6-decade) resolution. Its amplitude accuracy is 0.04% and distortion is less than 0.1%. With an optional amplifier housed in a separate chassis, you can increase the output to 1000V ac max. $3995. Delivery, 60 days ARO.

Electronic Development Corp, 11 Hamlin St, Boston, MA 02127. Phone (617) 268-9696.

Circle No 368

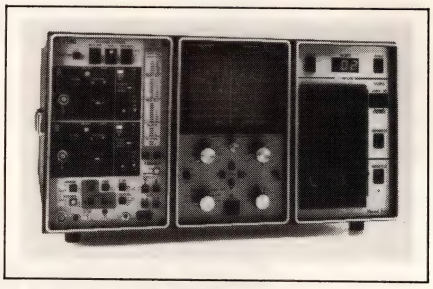


VLSI TESTER

The LT-1000 combines tester-per-pin and shared-resource architectures to test devices that have as many as 256 pins. In its double-pulse mode, the tester can provide stimuli at a 100-MHz data rate. The system's pin drivers can produce linear-edge test signals that rise to 5.5V in 1.6 nsec (10 to 90%). The basic data rate is 50 MHz; because the double-pulse mode uses a pin driver's own inhibit function, and not an adjacent pin, producing 100-MHz stimuli does not reduce the number of device pins the unit can drive. It does sacrifice the inhibit function on double-pulsing pins, however. The first system installed at your facility includes a program-development station with program-generation software, and a computer-controlled autocalibration station. The program-development and autocalibration stations need not be duplicated for subsequent systems installed at the facility. Initial system, $829,000. Average system cost for a 5-system installation, $736,000. Delivery, eight to 12 weeks ARO.

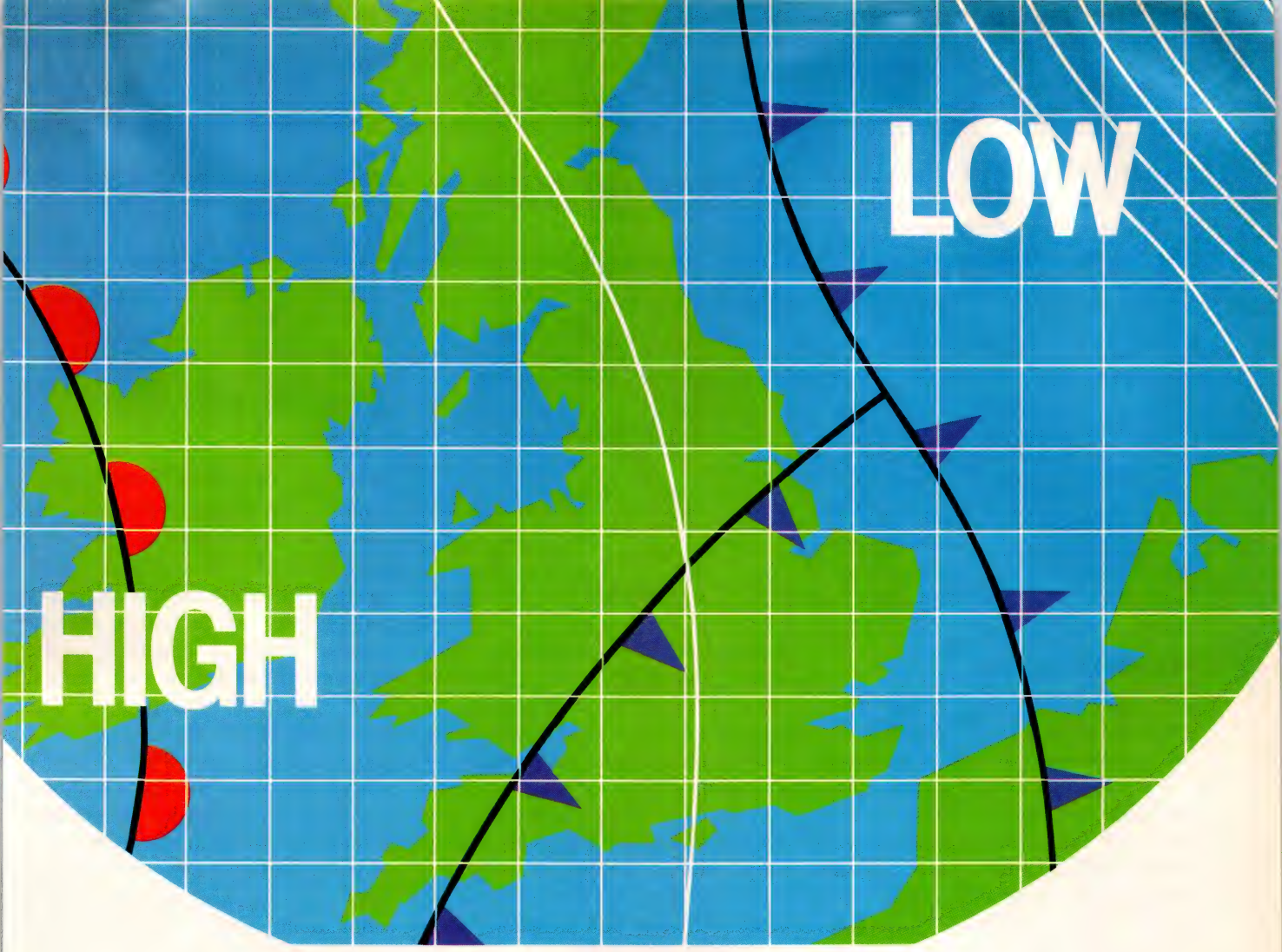
Tektronix Inc, Box 500, Beaverton, OR 97077. Phone (503) 627-7111. TLX 151754.

Circle No 367



SCOPE PLUG-IN

The 4180 dual-channel high-speed digitizing plug-in increases the acquisition speed of the vendor's 4094 digitizing scope to 200M samples/sec. You do not have to reduce the sampling rate if you install two of the plug-ins in one scope to obtain 4-channel data acquisition. The single-ended inputs have 1-MΩ input impedance and full-scale sensitivity from ±100 mV to ±40V. You can select a pretrigger delay as large as 99.9% of the sweep time or a post-trigger delay as large as 2^{25} sample intervals. The unit calculates FFTs and performs other mathematical operations on acquired data, such as



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virtual and exponential averaging. $7900. Delivery, 120 days ARO.

Nicolet, Test Instruments Div, Box 4288, Madison, WI 53711. Phone (608) 273-5008.

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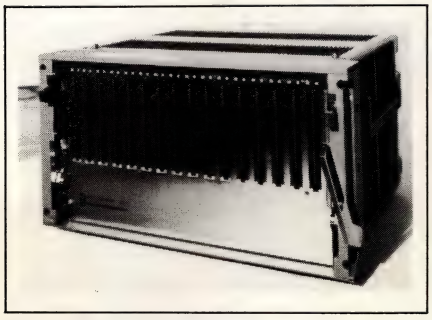


TEST INTERFACE

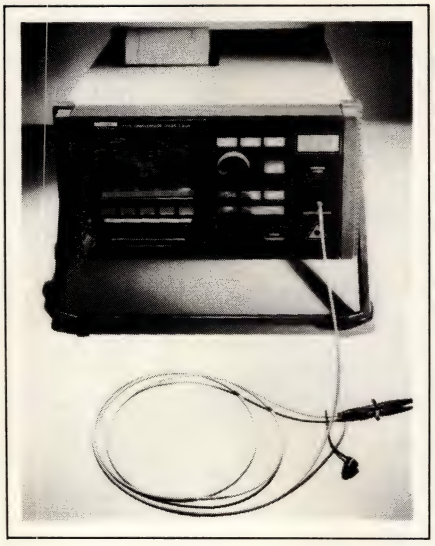
The UTI-1 routes signals between a unit under test (UUT) and test instruments such as digital multimeters; analog and digital signal sources; oscilloscopes; data recorders; and data analyzers. The device comes with an internal bus, a power supply that can provide power to the UUT, and an IEEE-488 interface. The vendor offers a variety of internally mounted, off-the-shelf support modules to facilitate connecting the UTI-1 to specific analog and digital test instruments, external power supplies, and stimulus sources. You can control the internal bus and the support modules via the IEEE-488 bus. Each type of UUT requires a separate interchangeable test adapter (ITA). By changing ITAs, you can use the same test setup to test many different devices. $7400.

Wandel and Goltermann Inc, 1030 Swabia Ct, Research Triangle Park, NC 27709. Phone (919) 941-5730. TWX 810-621-0002.

Circle No 386

FIBER TESTERS

The 7721, 7723, and 7725 optical time-domain reflectometers let you make bandwidth and attenuation measurements on fiber-optic cables. The instruments use menu and automatic setups to locate breaks in the fiber and to achieve repeatable



measurements of bandwidth, cable losses, and splice losses. The CRT trace of the cable's characteristic is fully annotated with the losses, and you can recall initial cable profiles—stored on an optional magnetic-tape cassette—for comparison purposes. An integral printer provides hard-copy results. A manual operating mode allows you to make additional measurements and to zoom in on areas of special interest.

The reflectometers are designed for 850-nm multimode, 1300-nm multimode, and 1300-nm monomode cables, respectively. In the first instrument, a fiber connector accepts several cable sizes and reduces the dead zone in the fiber to zero. The instruments for use with multimode fiber feature a backscatter single-way dynamic range (SWDR) of ≥25 dB, and the monomode instrument specs a backscatter SWDR of ≥24 dB. All the instruments have IEEE-488 and RS-232C interfaces and operate from ac line or 10 to 16V dc supplies. From Fr Fr 115,000 to Fr Fr 180,000.

Enertec Instruments, 5 rue Daguerre, 42030 St Etienne Cedex 2, France. Phone 77252264. TLX 300796.

Circle No 387

Solartron Instruments, 2 Westchester Plaza, Elmsford, NY 10523. Phone (914) 592-9168. TLX 145487.

Circle No 388

TESTER

The 4031 portable RF communications tester performs service, repair, and production testing on a wide array of radio-communications equipment—for example, military and private mobile radios, cellular radios, digitally encoded radio equipment, selective call radios, DTMF phones, and pagers. The tester has 2-μV input sensitivity and includes a spectrum analyzer that operates to 1 GHz and a digital oscilloscope with a 7-in. screen. The screen can simultaneously display as many as three simulated analog meter movements, which you can zoom to full screen size for better visibility. On-screen limit indications highlight out-of-limit conditions.

A microphone input allows you to perform voice-over testing of mobile and cellular radios, and a patented modulation technique provides pulse modulation of an RF carrier without carrier-frequency drift. You can program the tester using memory cards that contain as much as 100k bytes of operating system or of user-defined test sequences. An IEEE-488 interface is standard. Options include full-duplex operation, relay interface cards, and a user-definable data-transmission module. Around £9000.

Solartron Instruments, Victoria Rd, Farnborough, Hampshire GU14 7PW, UK. Phone (0252) 544433. TLX 858245.

Circle No 389

Solartron Instruments, 2 Westchester Plaza, Elmsford, NY 10523. Phone (914) 592-9168. TLX 145487.

Circle No 390

Continued on pg 92

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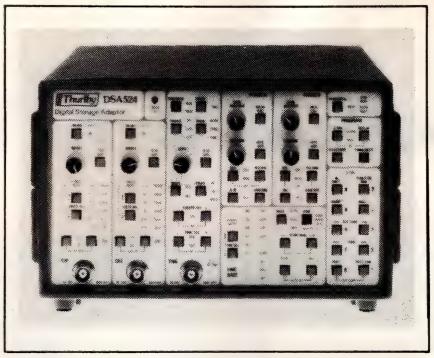
The second storage adapter has a capture memory of 4096 words per channel; the normal display mode shows a 1024-word window on the capture memory. A trace-compression mode allows you to display all 4096 samples on the oscilloscope, and a trace-magnification mode expands any 101-word section across the full screen width. This adapter has a trace memory of 1024 words per channel and normal and magnified display modes. Both adapters allow you to capture pretrigger trace information, and both provide digital post-trigger delay. The first adapter also offers delay by number of trigger events.



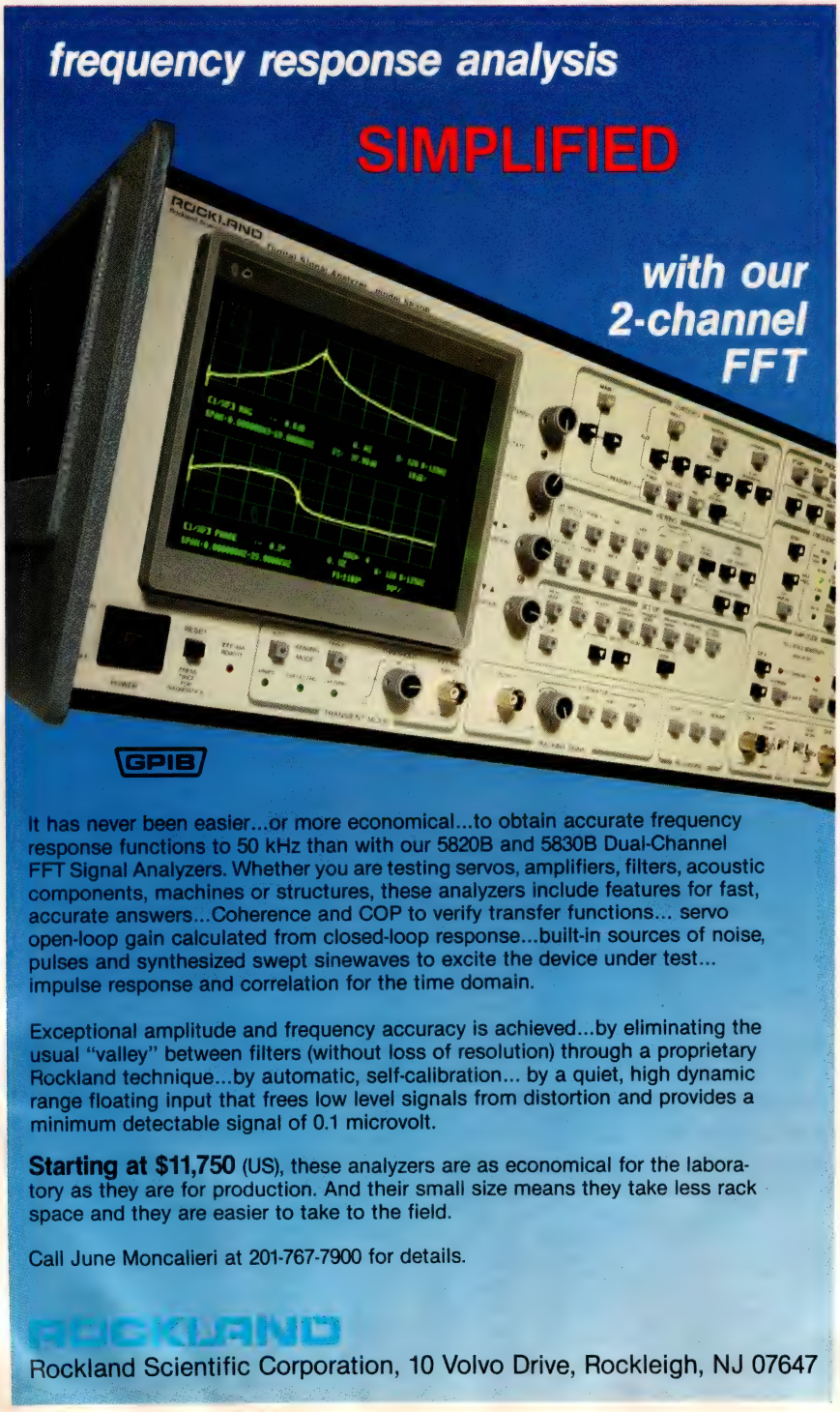
Additional features include CRT trace annotation, nonvolatile trace storage, and computation functions on and between traces. In addition, the first adapter offers linear or sine interpolation, digital averaging, and autoranging inputs. An RS-423 interface is standard, and an IEEE-488 interface is optional on both adapters. DSA524, £585; DSA511, £395.

Thurlby Electronics Ltd, New Rd, St Ives, Huntingdon, Cambridgeshire PE17 4BG, UK. Phone (0480) 63570. TLX 32475.

Circle No 391

BOARD TESTER

By simulating operation of the target system's μP, the B3T μP board tester allows you to run predefined,



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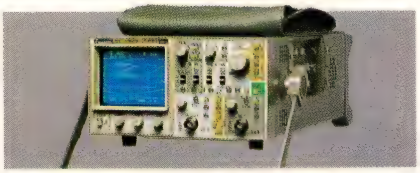

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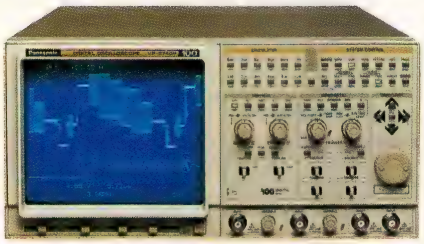

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functional test sequences to test a board's components. Interface pods, which plug into the board's μP socket, let you test boards based on popular 8-bit μPs and microcontrollers. Standard tests include detection of short circuits on data, address, and control buses; long and short RAM tests; and ROM checksum tests. You can also control and monitor individual μP control lines and memory and I/O read/write functions. Further, you can toggle the data and address buses, stimulate the board with walking data patterns, and disassemble program code into assembly-code mnemonics.

Other features of the tester include logic-analysis/stimulus and frequency probes that allow you to monitor and control a board's I/O ports, a 5V/1A power-supply output to power the board under test, and an RS-232C remote-control port. You can store as many as 1500 test instructions in the tester's internal nonvolatile memory or download test sequences from EPROM using the tester's ZIF socket. Test results are displayed on an LCD, and an integral printer provides hard-copy output. B3T, £1395; μP interface pods, £100 each.

Polar Instruments Ltd, Box 97, St Sampson's, Guernsey, Channel Islands, UK. Phone (0481) 53081. TLX 4191591.

Circle No 392

IN-CIRCUIT EMULATOR

The HMI-200-80 is a Z-80 in-circuit emulator that requires an IBM PC or compatible computer for operation. It supports Z80-, Z80A-, Z80B-, and Z80H-based target systems that use bank-switching and bank-addressing schemes to address as much as 256k bytes of memory, four times the maximum size normally associated with the Z80 Series μPs. The emulator's capabilities include an embedded logic-analyzer function, a pair of 72-bit-wide×4k-deep trace buffers with selective-trace capability, complex break and trigger points, a μsec-resolution interval timer, and two bank-selection schemes. The unit can support real-time emulation at clock rates of 8 MHz max or can operate in single-step mode. $4750.

Huntsville Microsystems Inc, Box 12415, Huntsville, AL 35802. Phone (205) 881-6005.

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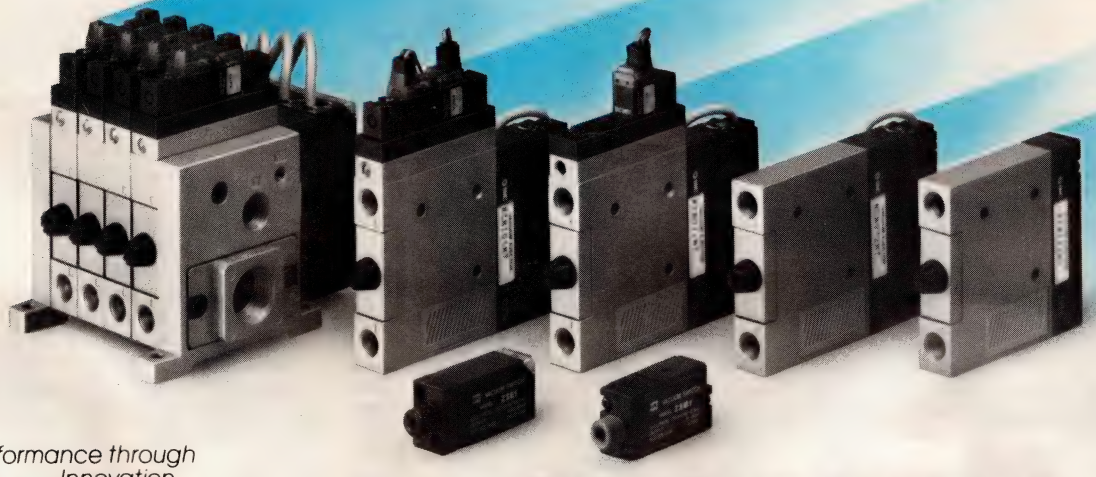

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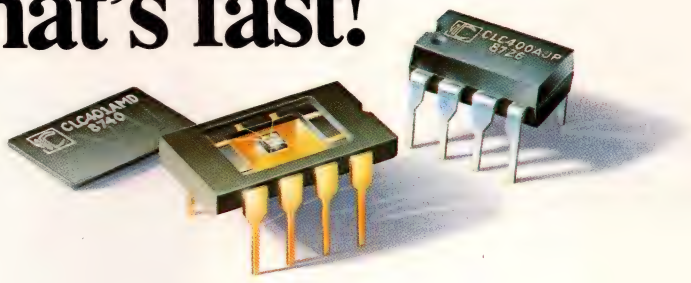

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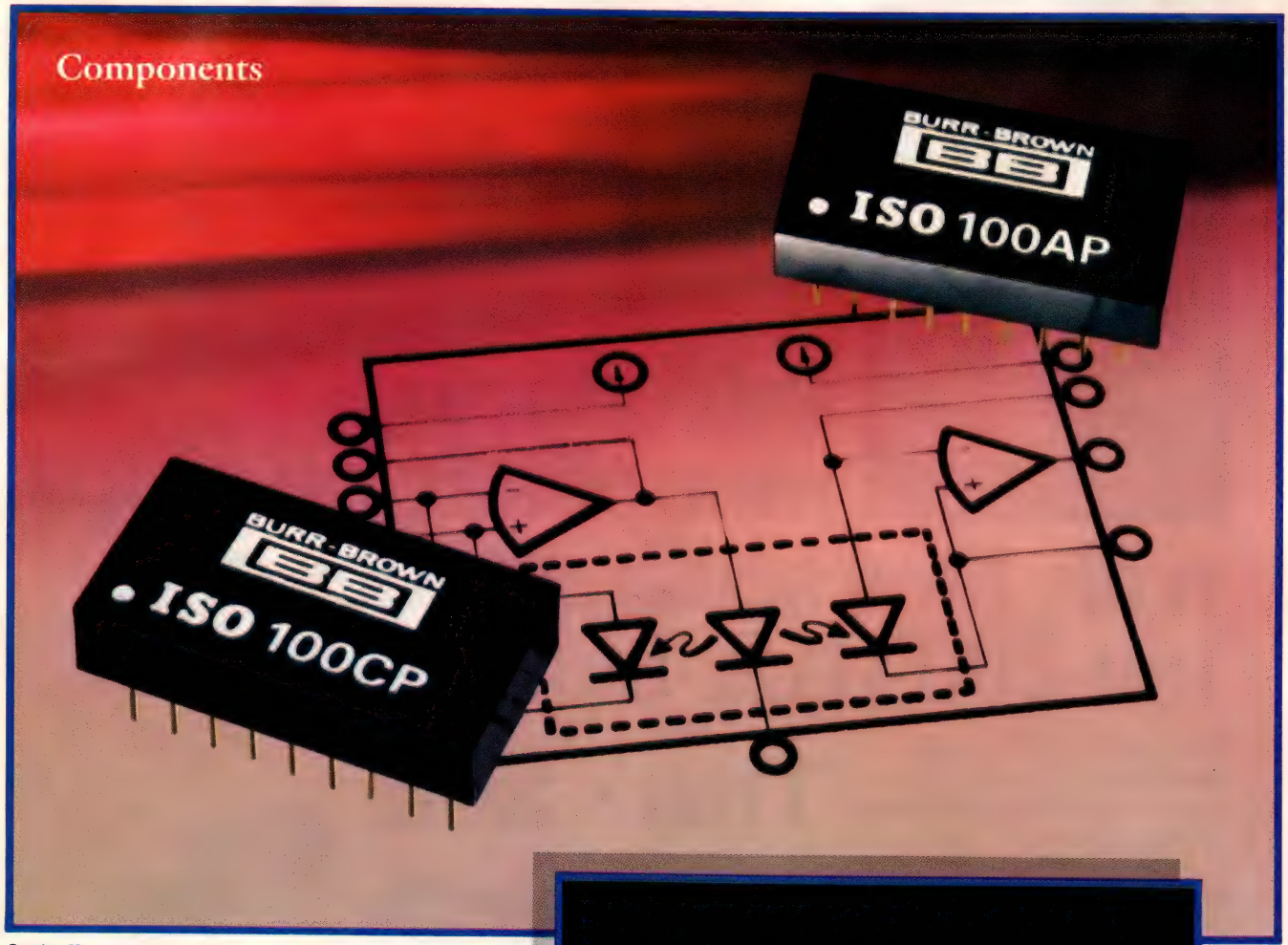


Optically coupled, 750V dc isolation amplifiers *(Burr-Brown Corp)*

Three-port isolation amplifier *(Analog Devices Inc)*

1500V rms, 2-in.-long×¼-in.-wide IA *(Analog Devices Inc)*

Isolation amplifiers break ground loops and achieve high CMRR

Small size and low cost are creating new applications for today's isolation amplifiers. Based on magnetic, optical, or capacitive techniques, these amplifiers can retrieve microvolt-level signals riding on thousands of volts, can block ground loops, and can reject otherwise catastrophic fault voltages.

Tarlton Fleming, *Associate Editor*

Isolation amplifiers (IAs) have traditionally found use in applications such as medical electronics, but don't overlook these units for other, more mundane applications. Indeed, IA manufacturers anticipate greater use of these amplifiers as more designers learn of the shrinking IA sizes and prices. Compact DIP and SIP versions are now available, and although IAs suitable for medical equipment still cost upwards of $100, versions rated for general-purpose use are available for as little as $25. And for less than $10, you can buy differential amplifiers that provide good common-mode rejection even though they don't offer the galvanic isolation of true IAs.

An isolation amplifier (sometimes called an isolator) provides differential amplification for signals over a typical range of 0 to ±10V while allowing virtually no current flow between the IA's input and output. Thus, large voltages between the input and output have negligible effect on the output signal, and no ground loop can encompass the input- and output-signal commons. You can introduce an IA to preclude the formation of troublesome ground loops, to reject large unwanted common-mode voltages, or to guard against the high voltages that might appear during a fault condition.

Like the earliest types, many of today's IAs include in the signal path a transformer that provides magnetic isolation. A major advantage of this type of IA is that it employs an additional transformer that delivers power across the isolation barrier to activate the IA's input stage. (Other types depend on an external dc/dc converter to supply isolated power to the input side.) Moreover, this input-stage supply voltage is usually also accessible for powering external circuits **(Fig 1)**.

Interwinding capacitance creates leakage

The nonconducting barrier in such units consists of a galvanic separation between primary and secondary windings within the transformers. Careful design allows this barrier to withstand thousands of volts and to exhibit only a few picofarads of stray capacitance between the windings.

Low capacitance is important because ac voltage across the barrier, such as pickup from the power lines, will couple through the interwinding capacitance and appear as noise mixed with the output signal. To reduce the interwinding capacitance and to increase the isolation voltage, Intronics introduces a third winding between the primary and secondary of each transformer **(Fig 2)**.

The majority of today's IAs continue to employ magnetic isolation. Many of these are modular or rack-mounted types that include filters and other special-purpose circuits. But by using custom ICs, miniatu-

An isolation amplifier provides differential amplification while allowing virtually no current flow between the input and output.

rized transformers, and automated surface-mount-assembly procedures, Analog Devices has produced a magnetically isolated IA—the AD202— in the form of an 11-pin single-in-line package (SIP) that measures only 2.08×0.625×0.250 in. (Actually, the package is a ZIP—a SIP whose pins are staggered in a zig-zag pattern.)

Miniature transformers pass AM signal

The AD202 contains two tiny transformers, one for the signal and one for power. You apply 15V, and an internal 25-kHz oscillator drives the power transformer's primary. The secondary winding connects to a rectifier and filter that can provide 0.4 mA at ±7.5V—enough isolated (and unregulated) power to operate external adjustment networks or low-power references and op amps. The 25-kHz signal also synchronizes the IA's amplitude-modulator and -demodulator circuits, which enable the precise transmission of dc levels across the isolation barrier.

Version AD202K of this IA can withstand a continuous voltage of 2000V dc or 1500V rms at 60 Hz between the input and output. Its common-mode rejection for a 60-Hz signal is 100 dB min (at unity gain, with a source impedance no greater than 1 kΩ). The nonlinearity error is 0.025% max over the ±5V input range, the typical −3-dB bandwidth is 5 kHz, and the settling time to within ±10 mV is about 1 msec. The total interwinding capacitance for the two transformers is less than 5 pF. Also available in a 2.10×0.70×0.350-in. DIP, the AD202K costs $32 (100).

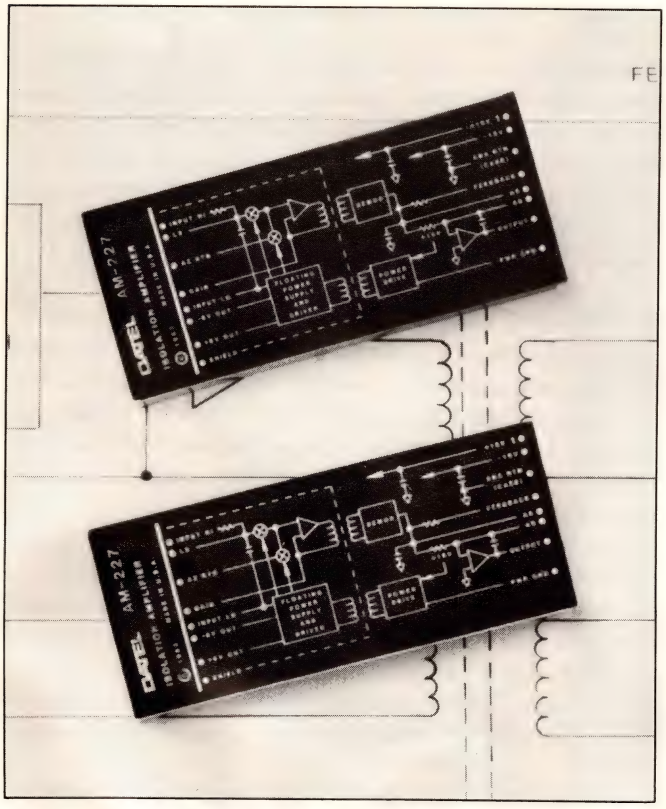


***Fig 1—Model AM-227 isolation amplifiers** from Datel can amplify 0- to 5-Hz signals with a gain of 10 to 1000 while rejecting common-mode voltages as high as 1000V dc. Moreover, they provide isolated power for external input circuitry.*

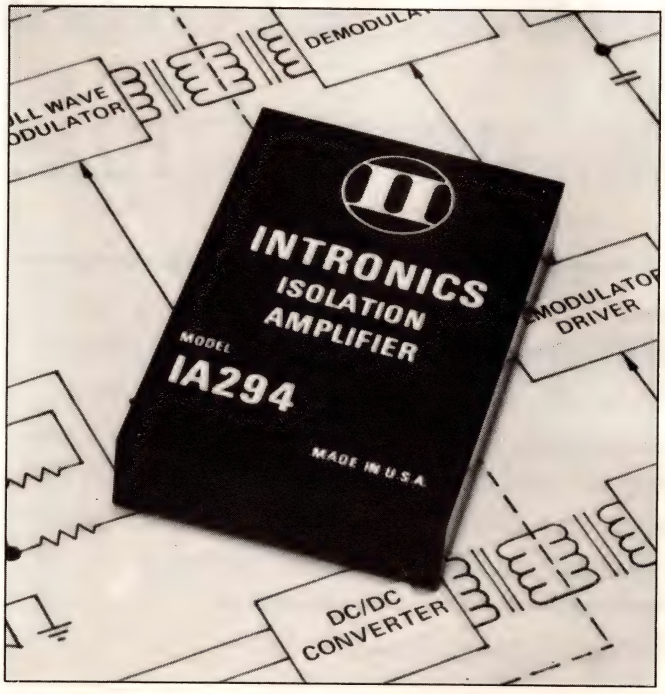


***Fig 2—Intended for medical applications,** this isolation amplifier from Intronics features an instrumentation-amplifier front end and a dedicated guard-drive amplifier. The common-mode voltage rating is 5000V dc continuous or 6500V pk. A third winding between the primary and secondary of each transformer reduces the interwinding capacitance and increases the isolation voltage.*

Clock-driven IAs allow synchronization

The AD204 is similar to the AD202 but requires an external 25-kHz, 15V p-p clock signal instead of the 15V supply. Both IAs include an uncommitted input amplifier that lets you buffer the input signal or introduce gain. The clock input drives the power transformer and thereby produces unregulated ±7.5V supply voltages at the IA's input side. This isolated supply can deliver as much as 2 mA for the operation of input preamps, semiconductor strain gauges, or other circuits.

In a multiple-IA system, you can drive AD204s in parallel from the same clock source to eliminate the

possibility of beat frequencies. (Analog Devices offers the AD246 for this purpose, a clock-driver IC that can drive 32 AD204s.) The AD204K costs $29 (100); the AD204J, $25 (100).

Another IA from Analog Devices, the AD210, provides isolated power to the amplifier's output port as well as the input port. (This arrangement lets you use the device as an input or an output isolator, and it provides protection from faults in the power source.) The unit's 50-kHz power oscillator and two power transformers generate separate ±15V supply voltages for each side of the isolation barrier; you connect only 15V to the amplifier.

Automation speeds amplifier assembly

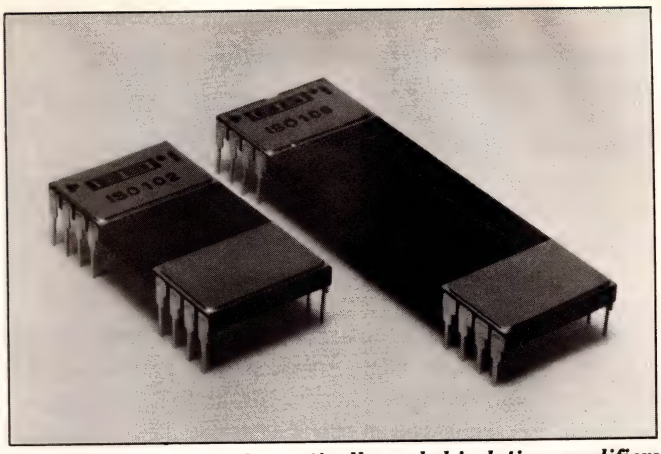
The AD210 has an uncommitted input amplifier and a unity-gain output buffer, and it includes a 20-kHz, 3-pole filter for removing output ripple and noise. Compared with the AD202/204, the AD210 offers wider bandwidth (−3 dB at 20 kHz), more isolated power (5 mA at ±15V), and higher common-mode voltage (±3500V dc or 2500V rms at 60 Hz). All three products feature surface-mounted components and automated assembly. The AD210AN comes in a 2.10×1.00×0.35-in. DIP and costs $47 (100).

Intronics offers a variety of modular, magnetically isolated IAs. For example, the IA296, a 3.53×2.53×0.63-in. module, suits medical applications. It includes an instrumentation-amplifier input and a guard-drive amplifier, and it exhibits unusually low input-voltage noise (3 μV rms from 10 Hz to 1 kHz). The device offers 5000V dc isolation and 170-dB CMRR (160 dB with a 5-kΩ source-resistor imbalance). Its price is $178 (100).

The Intronics $122 (100) IA175 comes in the same size module and has specs compatible with 12-bit data-acquisition systems. It specs 0.005% nonlinearity error and provides input/output isolation of 5000V dc or 3000V rms. Its bandwidth at −3 dB is 1 kHz. The IA175 includes an input amplifier, an output filter, and an 8-kHz power oscillator. It requires only 15V for operation.

Amplifier isolates low-frequency signals

The Intronics IA184/284 IAs are suitable for general industrial use. Both offer 2500V ac or dc isolation, 1-kHz bandwidth, 126-dB CMRR, and 0.025% nonlinearity error. The IA184 also offers provision for externally synchronizing the internal oscillator. Both units are packaged in modules that measure 1.5-in. square and 0.64 in. high. Prices are $57.30 (100) for the IA184 and $51 (100) for the IA284.



Capacitively coupled, hermetically sealed isolation amplifiers *(Burr-Brown Corp)*

Analogic and Datel offer similar magnetically coupled IAs for the amplification of low-level, low-frequency signals in the presence of high common-mode interference. Analogic's MP227A and Datel's AM-227 have user-selectable gain ranges of 10 to 1000 and a −6-dB bandwidth of 5 Hz (set by a 1-pole input filter and 2-pole output filter). These IAs provide 1000V dc isolation, achieve a 166-dB (min) CMRR, and come in 2.76×1.18-in. 16-pin DIPs. The MP227A costs $65 (100); the AM-227, $47 (100).

Burr-Brown, too, offers a transformer-coupled IA—Model 3656—but for new designs the company recommends its capacitively coupled or optically coupled models. Among these newer alternatives is a novel type of isolation amplifier that Burr-Brown introduced last year, in which two small (3-pF) capacitors differentially couple a desired signal across the isolation barrier. The ISO106, for example, withstands 4950V dc min and provides minimum CMRRs of 140 dB (dc) and 125 dB (60 Hz ac). Its small-signal bandwidth is a respectable 70 MHz. The company has other products of this type under development and plans to introduce them in 1988.

Isolation capacitors must be small

Capacitive coupling is a simple, rugged, and inexpensive technique when compared with transformer (magnetic) coupling. On the other hand, it represents a compromise that carries two significant penalties. Although the capacitors differentially couple a signal of interest, their sum (6 pF) behaves as an undesirable stray capacitance, coupling unwanted ac common-mode currents across the barrier. The coupling capacitors are made as small as practical to minimize this effect.

The other disadvantage is simply that capacitors cannot transfer power across the isolation barrier, and IAs employing the technique require nominal ±15V supply voltages on both sides of the barrier. Burr-Brown offers two dc/dc converters for this purpose: the PWS725 (1500V rms isolation) and the PWS726 (3500V rms isolation), which cost $21.30 and $27.70 (100), respectively.

Capacitive coupling is a simple, rugged, and inexpensive technique when compared with transformer (magnetic) coupling.

Burr-Brown cites its *Reliability Report #000396* as evidence that constructing an IA with capacitive-coupling hardware bestows high reliability on the device. Each barrier capacitor in the ISO106 consists of thick-film, interlocking spirals of tungsten, embedded within the IA's ceramic substrate. The result is a 3-chip hybrid device that the company claims is the industry's first hermetically sealed isolation amplifier. The report shows that no ISO106s failed when subjected to a continuous barrier stress of 3500V rms at 25°C for 1008 hours. This test result is equivalent to a mean time-to-failure spec of 1660 years.

The ISO106 and the ISO102 are 16-pin devices in 600-mil-wide DIPs. The ISO106 package length is that of a 40-pin DIP, however, and the ISO102 package is the length of a 24-pin DIP. Physical separation in the longer package supports a higher minimum guaranteed isolation voltage: 3500 vs 1500V continuous at 60 Hz. The barrier voltage has little effect on the output signal for barrier-voltage slew rates of less than 100V/μsec. What's more, the IA can withstand, without damage, barrier-voltage slew rates to 100 kV/μsec.

These IAs employ digital signal transmission across the barrier. A voltage-controlled oscillator (VCO) on the input side drives the two barrier capacitors. A sense amplifier on the output side receives the pulses and drives a phase-locked loop (PLL). Because the input VCO and an identical VCO within the PLL operate at the same frequency, their input voltages are identical. This output-side, VCO-input voltage is the desired output signal; it becomes the IA's output voltage after passing through a 100-kHz second-order active filter.

Optical isolation is the remaining practical alternative for isolation-amplifier design. In this approach, an LED on the input side converts the analog input to a corresponding light level, which illuminates a photodiode on the output side. Bandwidth, speed, and cost were original advantages for this IA type, but recent transformer-based IAs offer comparable performance in those areas.

Optically coupled IAs have a niche

Like capacitively coupled IAs, the optically coupled types require an isolated power source to operate circuits on the isolation barrier's input side. (For plenty of applications, such power is already available or is easily added.) You should also be aware that, over time, all optocouplers exhibit a degradation of the current-transfer ratio (CTR).

Burr-Brown offers three optically coupled IAs, all of which employ a circuit technique that counteracts the effects of degradation in the LED output. The company recommends Model ISO100 for new designs. This device specs a 750V isolation voltage, 146-dB CMRR (at a gain of 100), a 60-kHz bandwidth, and a 0.3-μA barrier-leakage current (at 240V, 60 Hz). The package is an 18-pin, 1.0×0.5×0.2-in. DIP, and the price is $25.50 (100).

The ISO100 is a current-input, voltage-output device; you convert an input voltage to current by adding an external resistor. The amplifier's input stage drives an LED that equally illuminates two closely matched photodiodes. One photodiode resides on the other side of the isolation barrier, where a current-to-voltage amplifier converts the diode current to an output voltage for the IA.

The other photodiode connects to the input stage's

For more information . . .

For more information on the isolation amplifiers mentioned in this article, contact the following manufacturers directly or circle the appropriate number on the Information Retrieval Service card.

Analog Devices Inc
Box 280
Norwood, MA 02062
(617) 329-4700
TWX 710-394-6577
Circle No 351

Analogic Corp
Audubon Rd
Wakefield, MA 01880
(617) 246-0300
TWX 710-348-0425
Circle No 352

Burr-Brown Corp
Box 11400
Tucson, AZ 85734
(602) 746-1111
TWX 910-952-1111
Circle No 353

Datel
11 Cabot Blvd
Mansfield, MA 02048
(617) 339-3000
TWX 710-346-1953
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Intronics
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Newton, MA 02158
(617) 964-4000
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Ohio Semitronics Inc
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(614) 486-9561
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CIRCLE NO 98

NEW!

A LOW PROFILE PCB SWITCH...

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The new Series 98 from EAO has the great styling of a low profile control with an important difference: it's the only low profile PCB switch that's completely sealed. Built to IP-67 standards (similar to NEMA 4 and 13), this newest EAO switch remains watertight in up to 3 feet of water at temperatures from −25°C to +85°C.

Watertight seals aren't all. The Series 98 has gold plated, low bounce contacts with an estimated lifetime of 5 million operations. Rated at 50 VAC/72 VDC @ 100mA; 3W maximum, it's available in three sizes and several configurations including non-illuminated, illuminated with one or two LED's, momentary or maintained action (Form C), four cap colors and a film insert.

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CIRCLE NO 16

summing junction—an arrangement in which negative feedback forces the diode to produce a current equal to the IA's input current. Accordingly, the IA's transfer function depends mainly on optical matching of the two photodiodes, not on the LED's absolute output level. Ideally, the photodiode currents are equal during operation. Laser trimming improves the current matching, and negative feedback enhances the amplifier's linearity.

Consider the alternatives to an IA

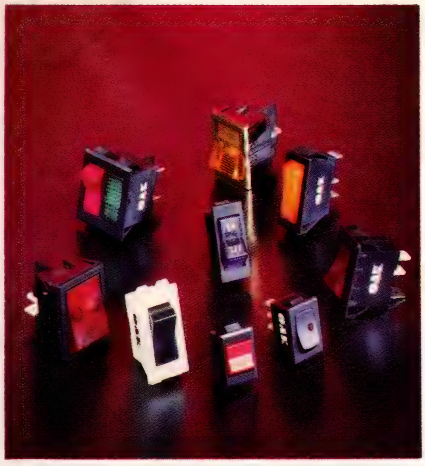
Your application may not require a full isolation amplifier—if so, Burr-Brown's Model INA117 differential amplifier offers an alternative. For applications that require common-mode rejection of ±200V or less but do not require galvanic isolation, you can save money by using the INA117; the INA117AM version costs $7 (100).

The monolithic INA117's laser-trimmed resistor network attenuates the input signal and provides 80-dB rejection of the common-mode voltage. Feedback around the amplifier restores the differential-mode gain to unity. This device's dynamic response beats that of most IAs: 200-kHz, −3-dB bandwidth; 30-kHz full-power bandwidth; and 10-μsec settling time (to within ±0.01%).

Certain rack-mounted amplifiers offer another alternative to the galvanically isolated IA. The product line at Pacific Instruments, for example, includes amplifiers with ±300V common-mode ratings. Magnetic isolation in these units allows the power supply to float with the common-mode voltage, but the signal path does not contain galvanic isolation. Typical products are the Model 8655 transducer amplifier ($875 each) and the Model 3150 instrumentation amplifier ($425 each). The 8655, for instance, is a line-powered, rack-mounted instrument that is 5.25 in. high and 1.63 in. wide.

Finally, Ohio Semitronics offers a variety of transducers that sense current, voltage, and power at high voltage levels and produce a proportional output. Transducers of the VT8 Series, for instance, sense the rms level (dc to 5 kHz) of voltages from 50 mV to 1000V while guaranteeing 1500V isolation from input to output. You specify the output response as 1 mA full scale, 10V full scale, or 4 to 20 mA. The price for a 1000V, 10V-output version is $350. **EDN**

Article Interest Quotient (Circle One)
High 473 Medium 474 Low 475



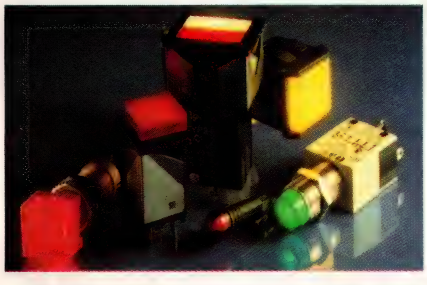
Off-The-Shelf Rocker Switches To Fit Your Design Parameters

Oak rocker switches are available in an assortment of designs, colors, sizes and styles to retrofit most existing design parameters. These attractive and highly-reliable switches are available in single or double pole, lighted, non-lighted or LED varieties. Choose from 6 standard colors and 9 profiles. Quick Connect terminations are standard, with other terminations available.

Oak rocker switches' off-the-shelf capability ensures prompt delivery. UL and CSA approved. Most have VDE, BEAB and SECV approval.

Contact: Oak Switch Systems Inc.
P.O. Box 517
Crystal Lake, IL 60014
Phone: 815/459-5000

CIRCLE NO 99



Lighted Pushbutton Switches Meet Military, Commercial Specifications

Oak's Optolite lighted pushbutton switches and indicators are available in a wide variety of sizes to meet most design requirements. They feature nine custom colors, eleven pushbutton styles, custom legends including dual lamp/split legends, and choice of mounting options.

A wide range of electrical ratings (dry circuit to 15 amps) and contact configurations are available in both alternate and momentary operation with up to 10 million duty cycles. The switches are UL, CSA listed and many are available with international approvals.

Contact: Oak Switch Systems Inc.
P.O. Box 517
Crystal Lake, IL 60014
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CIRCLE NO 100

Standard and Custom Solenoids For Almost All Circuit Designs

Oak Switch System's extensive line of rotary and linear solenoids include box frame, tubular, flat pack, and rotary selector. All are engineered and manufactured to meet stringent quality standards.

Oak has standard solenoids for virtually any force/stroke requirement. Oak engineers will also custom design rotary or linear solenoids to meet client specifications.

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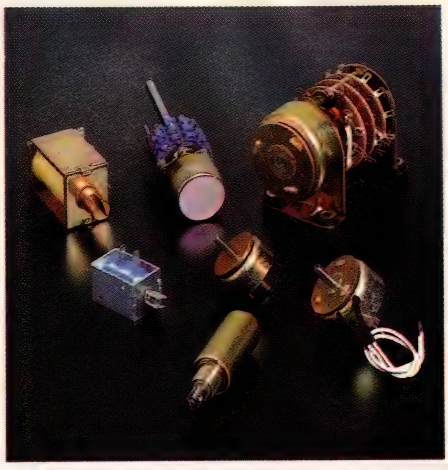
CIRCLE NO 101



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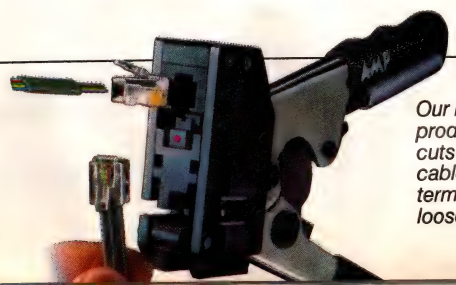
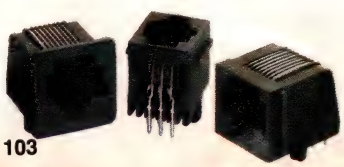
AMP Interconnecting ideas



Our modular plug production hand tool cuts cable, strips cable jacket and mass terminates loose piece plugs.

CIRCLE NO 103



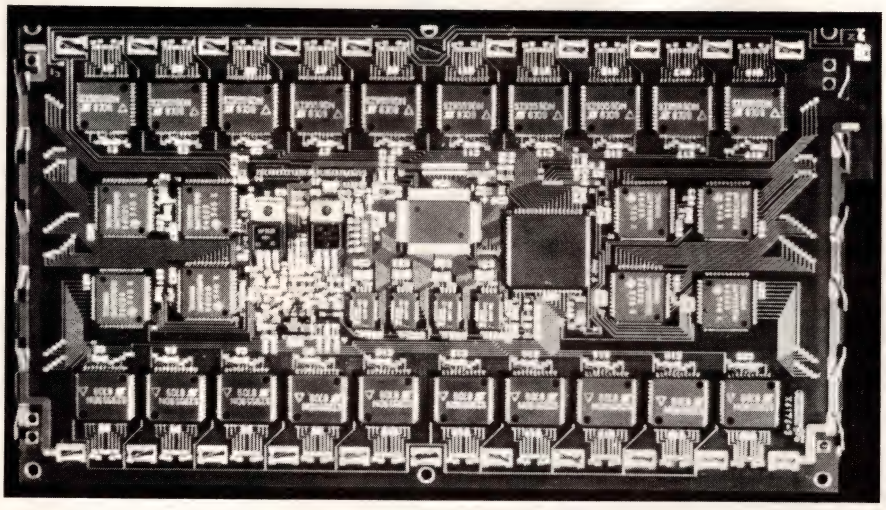
AMP modular jacks are U.L. listed. In top-entry and flanged or flangeless side-entry versions.

Bright, 640×200-pixel EL display offers high contrast, long life

Providing brightness and viewing-angle specs comparable to a CRT's, the dc-driven ELIC electroluminescent (EL) display panel is the thinnest display available. Including driver electronics, this flat-panel display has a thickness of less than 0.575 in.

This resistive dc EL display operates at voltages from 120 to 180V. As a result, the ELIC avoids the voltage-induced pixel-failure problems (caused by thin-film dielectric breakdown) that plague ac EL displays. The 620×200-pixel dc EL panel consumes 20W typ. It specs a pixel luminance of 25 fL, with a degradation not exceeding 30% in 10,000 hours.

The display provides a flicker-free image and a viewing angle of greater than 120°. It operates over 0 to 55°C. The frame rate is typically 60 Hz, and the unit can withstand a shock as great as 50g.



You can select from two versions of this amber display. The ELIC-G000 has an 8.956×3.898-in. active display window. Including the bezel, the overall package measures 10.74×5.9×0.6 in. The active display area in the ELIC-I000 measures 7.7×4.8 in.; the overall package is 10.54×7.8×0.6 in. The -G000 has 0.01×0.0171-in. pixels, and the -I000's pixels are 0.008×0.02 in. Prices start at $800 for a single display, but drop to $385 in 5000-piece quantities.

Cherry Electrical Products, 3600 Sunset Ave, Waukegan, IL 60087. Phone (312) 360-3500.

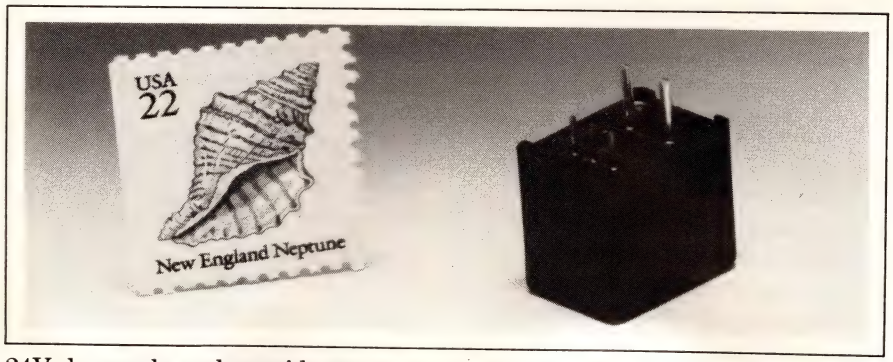
Circle No 711

Miniature digital current sensors operate in harsh environments

The CS Series current sensors include miniature series-connect versions. The sensors are fully encapsulated for exposure to harsh environments, and you can mount them on pc boards. They provide in-line current sensing for applications such as motor control, power-loss detection, and performance verification.

The series-connect digital current sensors are available with different operating points, and they can all be interchanged. The sensors are protected against transients, and the output voltage is isolated from the sensed current input.

The sensors operate from a 4.5 to



24V dc supply and provide an open-collector output that changes to a low state when the sensed current exceeds the operating point. Their response time is 60 μsec, and their solid-state construction provides for consistent repeatability. The sensors' operating-temperature range spans −25 to +85°C. $19.50. Delivery, six to eight weeks ARO.

Micro Switch, 11 W Spring St, Freeport, IL 61032. Phone (815) 235-6600.

Circle No 713

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10A, SPDT Switching
T70 relays are low-cost, SPDT units offering silver or silver-cadmium oxide contacts for loads from 1 milliamp through 10 amps. Available with an immersion cleanable, sealed case.

4,000V Isolation
RK series relays feature 8 mm coil-to-contact spacing for 4,000 volt isolation. SPDT models switch loads to 20 amps, and DPDT models switch up to 5 amps. Both sealed and unsealed versions are offered.

30A Workhorse
T90 relays have SPDT contacts of silver-cadmium oxide for 30 amp loads or silver for loads up to 15 amps. Available as an open relay or sealed for immersion cleaning. A snap-on dust cover is offered for open models.

Quick Connects, Too
T91 relays feature the same ratings as T90 relays and provide both quick connects and printed circuit terminals for load connections. Sealed and dust cover versions are available. Optional case provides flanges for panel mounting and quick connects for all connections.

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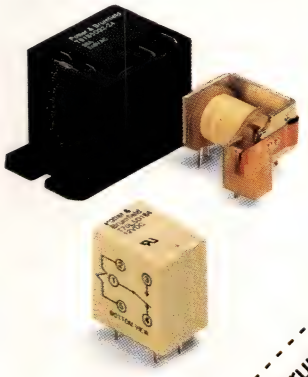

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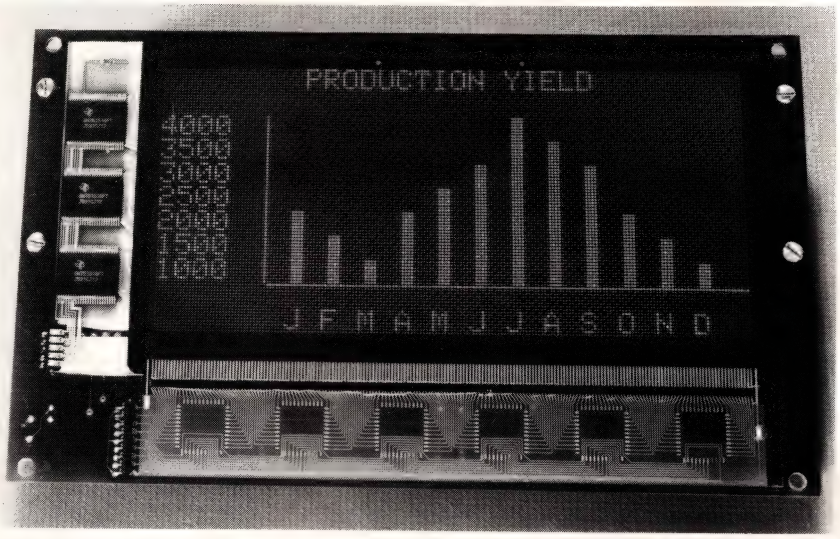
EDN 122487

CIRCLE NO 86

Dot-matrix graphics display includes μP-based controller

Model APD-192G088-1 is a 192-column×88-row graphics display. The full-field dot-matrix design includes drive electronics and a μP-based controller. You can program the display to operate in serial or parallel mode.

The APD-192G088-1 contains all the refresh memory, character-generation capability, and control logic it needs to serve as a direct readout. Single- and dual-byte commands control complex display tasks such as scrolling or line and character insertion. Its 4k×8-bit EPROM generates 256 characters: 128 ASCII characters and 128 block graphics characters. Alternate character sets can be programmed by the factory or by you.



The display measures 10.35×6×2.2 in. and has a 7.66×3.5-in. viewing area. It's also available with circuitry that interfaces directly to CRT controllers. $699 (100).

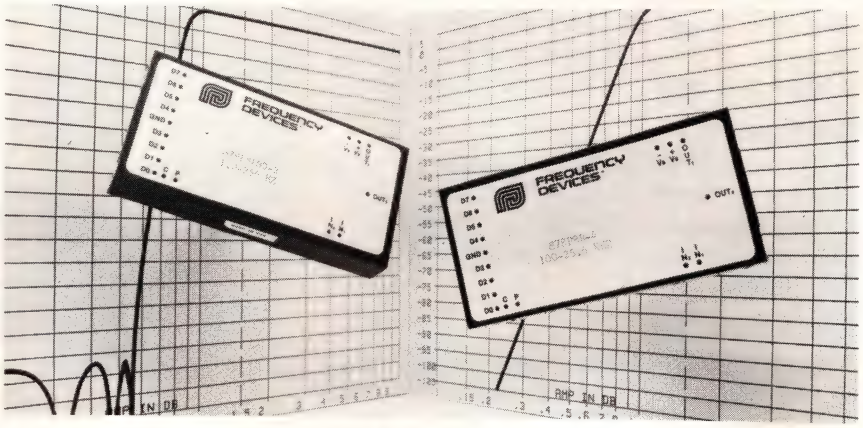
Dale Electronics Inc, 2064 12th Ave, Columbus, NB 68601. Phone (402) 564-3131.

Circle No 712

Programmable active filters feature 256:1 tuning range

Digitally programmable active filters in the 878 Series let you select a corner frequency for a highpass filter over a 256:1 frequency range. The units contain 8-bit CMOS-clocked D latches that can be digitally configured to operate in any of three modes: They can transfer frequency-control input data into the latches on the strobe's (clock's) rising edge, they can transfer control input data on the strobe's falling edge, and they can continuously follow the frequency-tuning input data in a nonlatching transparent mode.

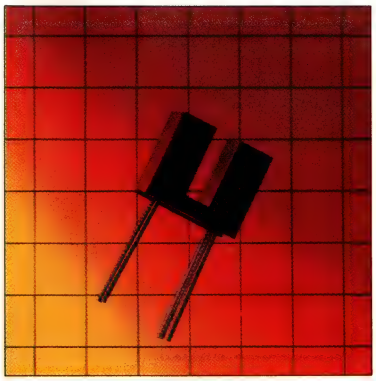
The 10 models in the series offer a choice of 8-pole Butterworth and elliptic transfer characteristics. Each model is available with one of five factory-set tuning ranges: 0.1 to 25.6 Hz, 1 to 256 Hz, 10 to 2560 Hz, 0.1 to 25.6 kHz, or 0.2 to 51.2 kHz.



All 878 Series products are complete filters that require no external components or adjustments and operate from noncritical ±12 to ±18V power supplies. The modules come in 2×4×0.4- and 2×4×0.6-in. sizes. Their input and output impedances are 200 kΩ and 10Ω, respectively. $300.

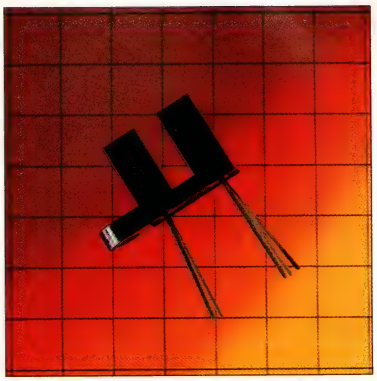
Frequency Devices Inc, 25 Locust St, Haverhill, MA 01830. Phone (617) 374-0761. TWX 710-347-0314.

Circle No 715



LOW COST WITH LOGIC

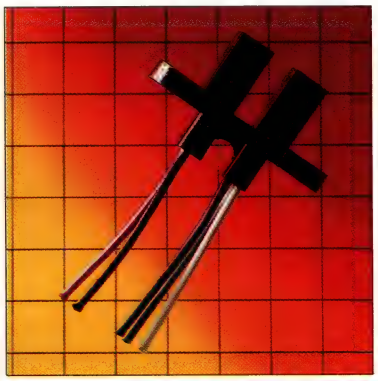
Need logic output? The KLT100 Series interrupters offer high speed OPT-IC-I photo-IC's with optional output geometries and guaranteed logic levels saving follow-on circuitry required by most standard phototransistor outputs.



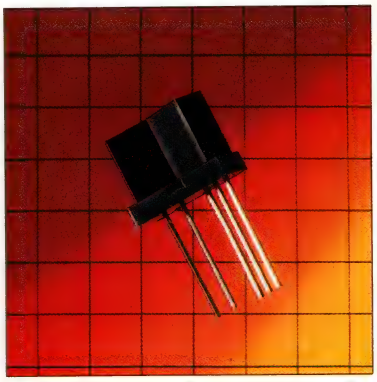
LOGIC WITH REGULATOR

Have requirements other than TTL? The KLT200 Series interrupters offer an onboard regulator on the OPT-IC II photo-IC's expanding the operating supply voltage from 4.5 to 16 volt range with no appreciable increase in required supply current.

EFFECTIVE OPTIONS FROM OPTEK TECHNOLOGY, INC.



Four new standard optoelectronic devices from Optek give you more choices for high-speed electrical-mechanical applications. Call Optek for samples or data sheets. If you have a special application, give us your specs, and we'll **customize** the parts you need.



LOW-POWER OPTION

Have system power constraints? The KLT300 Series interrupters feature the OPT-IC III photo-IC's with extremely sensitive thresholds enabling LED drive currents as low as 5 mA.

FINALLY, A HIGH-CONTRAST REFLECTIVE

Marginal contrast ratios? The KR100 Series reflective assemblies feature phototransistors designed to decrease low-level light gain while not affecting the high-level light gain.

OPTEK

Optek Technology, Inc.
345 Industrial Blvd.
McKinney, Texas 75069

Phone 214/542-9461
Fax 214/542-1739

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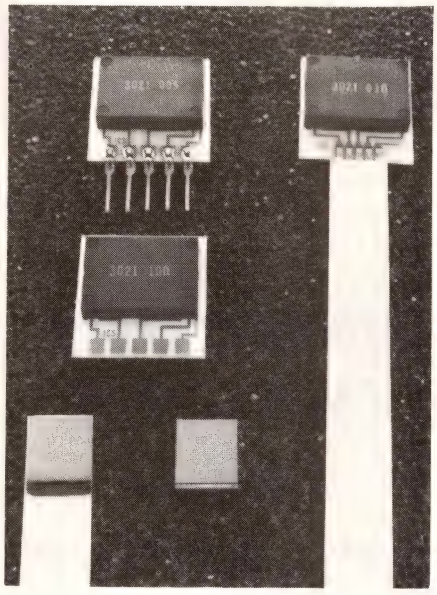
CIRCLE NO 50

Small silicon-based sensors monitor acceleration, vibration, and shock

Model 3021 piezoresistive, full-bridge accelerometers monitor acceleration, vibration, and shock. They exploit the mechanical and electrical properties of silicon to develop long-term stability. The silicon structure of the sensors consists of suspended beams that are implanted with piezoresistors. Each accelerometer chip measures only 7.9×7.3 mm. Because of a novel 3-layer silicon structure, the device can act as its own housing. The accelerometer is well suited for applications in which a heavier device would impede the movement of the structure it's attached to.



Model 3021 accelerometers are designed to operate at 5V, and they achieve full-scale sensitivities of more than 50 mV while operating in the range from ±5 to ±100G. The sensors are designed with built-in overforce stops, and they have a damping factor of 0.707 to provide critical damping. Alternate damping ratios are available. The temperature dependence of the damping is controlled to more than ±10% over the entire operating range. $87. Delivery, stock to eight weeks ARO.

IC Sensors Inc, 1701 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1800.

Circle No 714

Conductive-rubber keyboards feature tactile feedback, suit harsh environments

The SF62000-Input keyboards provide the environmental sealing you'd associate with membrane keyboards, but have tactile feedback similar to that of full-travel keyboards. Their environmental sealing exceeds BS-5490 class IP67 requirements, suiting them for use under wet, corrosive, or otherwise hostile conditions. Standard versions include 4-, 12-, and 16-position keyboards and a "qwerty" keyboard.

The keyboards incorporate a 1-piece silicone-rubber molding that is profiled, providing raised keys. The silicone-rubber molding fits over a metal backplate that supports a plastic film on which the switch-contact traces are printed. The plastic film also provides a flexible lead-out for connections to the switch matrix; the leadout is terminated in a 0.1-in.-pitch connector.

The switches have a maximum contact bounce of 5 msec and a maximum contact resistance of 200Ω. You can operate the switches at voltages as high as 24V dc and at currents as high as 50 mA. The force required to operate each key is typically 1.16 oz (33g). The vendor claims the keyswitches can typically withstand 2 million operations without showing any signs of silicone-rubber fatigue or unacceptable degradation in switch performance. The keyboards operate over −55 to +125°C, so they're suitable for use in military equipment. The 4-position keyboard is $24; the qwerty keyboard costs $75.

Marconi Electronic Devices Ltd, Microsystems Div, Hargreaves Rd, Groundwell Industrial Estate, Swindon SN2 5BE, UK. Phone (0793) 727005. TLX 444460.

Circle No 716

Marconi Electronic Devices Inc, Microsystems Div, 45 Davids Dr, Hauppauge, NY 11788. Phone (516) 231-7710. TLX 275801.

Circle No 717

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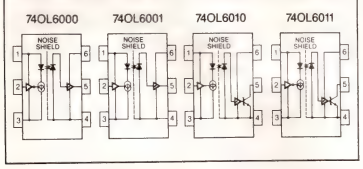
PART NUMBER	LOGIC COMPATIBILITY		LOGIC FUNCTION	OUTPUT CONFIGURATION
	INPUT	OUTPUT		
74OL6000	LSTTL	TTL	BUFFER	TOTEM POLE
74OL6001	LSTTL	TTL	INVERTER	TOTEM POLE
74OL6010	LSTTL	CMOS	BUFFER	OPEN COLLECTOR
74OL6011	LSTTL	CMOS	INVERTER	OPEN COLLECTOR



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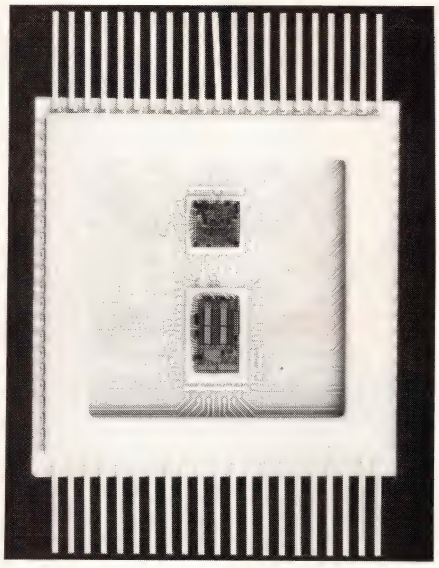
In Canada: Arrow, Cardinal Industrial, Future, ITT Multicomponents-RAE.

CIRCLE NO 51

High-speed, 8-bit A/D flash converter includes onboard track-and-hold circuit

The TKAD20C is an 8-bit, hybrid A/D converter that can digitize high-speed, single-shot analog input signals from dc to 125 MHz at a conversion rate of 250M samples/sec. Featuring input-signal bandwidths to 1.3 GHz, the device also has a built-in track-and-hold circuit for accurate, high-speed data conversion. Further, it includes a selectable demultiplexer, which gives you the option of configuring the TKAD20C to transmit data at an 8-bit, 250-MHz data rate or a 16-bit, 125-MHz data rate.

The converter also features a 50Ω input impedance, and its <3-psec aperture jitter gives it an effective-bit accuracy of seven bits at 125 MHz typ. (Effective-bit performance is a measure of the true signal accuracy of the device; this measure takes aperture jitter, noise, and distortion into account.)



The TKAD20C contains a track-and-hold (T/H) circuit that enables the device to follow extremely fast signals until it's told to hold the signal for the A/D converter to digitize. The T/H circuit's voltage gain of four reduces the differential-input-signal requirements to 270 mV. The converter operates from a ±5V supply, typically dissipates 5W, and is housed in an 84-pin ceramic package. The commercial version of the part costs $850.

Tektronix Inc, Box 1700, Beaverton, OR 97075. Phone (800) 835-9433 ext 100.

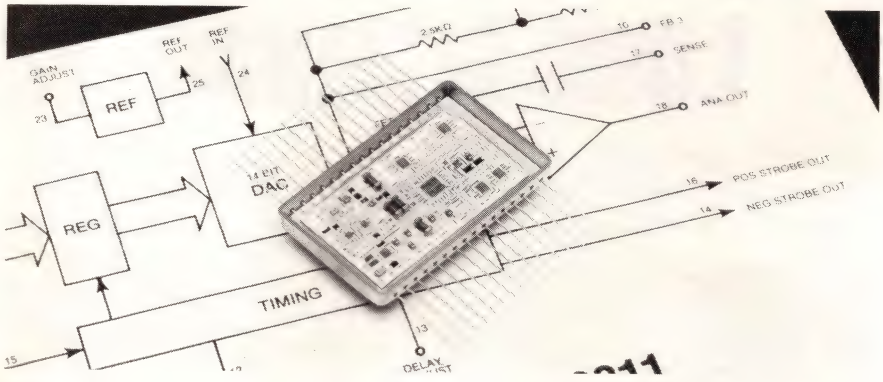
Circle No 718

14-bit, deglitched hybrid DAC fits surface-mount applications

Assembled in a 32-pin flatpack measuring 1.8×1.1×0.2 in., the DAC-02311 D/A converter delivers 14-bit, 10-MHz deglitched performance. The device includes input storage registers, a 14-bit DAC, a track-and-hold deglitcher, and precision reference and timing circuits.

With external jumpers, you can program the DAC's output voltages to ±10V, ±5V, ±2.5V, 0 to −10V, or 0 to −5V. The device is available in 13- and 12-bit linearity grades, and it has 14-bit resolution. Its settling time (to ±0.5 LSB) for a full-scale ±5V output change is 1 μsec. For small-signal stepping, its word rate can reach 10 MHz.

The DAC begins operating when a strobe-in signal is applied to it. At that time, the input registers are updated and the deglitcher is placed in hold mode for approximately 50 nsec. During the hold mode, the device's analog output remains constant while the internal DAC's glitch settles. After the glitch disappears, the DAC is placed in track mode and the output moves smoothly to its new voltage. For LSB changes, the settling time is 50 nsec.



The converter allows you to make external pedestal, delay, gain, and offset adjustments. You can use an external potentiometer to zero the pedestal error or to match two DACs in X- and Y-channel applications. The DAC requires 15V dc at 50 mA max, −15V dc at 35 mA max, and 5V dc at 45 mA max. From $245; delivery, stock to eight weeks.

ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 510-228-7324.

Circle No 719

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CIRCLE NO 52

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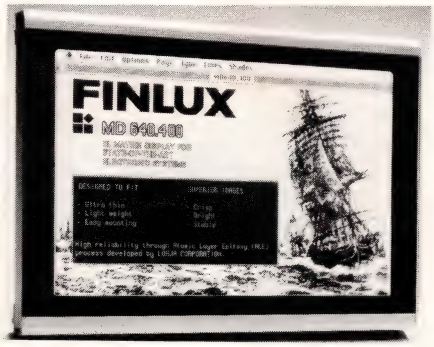
Electroluminescent display provides graphics and 25-line×80-column text

The Finlux MD640.400 flat-panel electroluminescent display has a screen resolution of 640×400 pixels, allowing you to display high-resolution graphics or 25 lines of text at 80 characters/line. The display comes with a display-driver board and power supply and requires only TTL-level video data, a video clock, and horizontal and vertical sync-pulse inputs. It's designed to scan at a refresh rate of 60 Hz.

Comprising a matrix of 0.22-mm square pixels on a 0.3-mm pitch (which is equivalent to 83 pixels/in.), the display produces a flicker-free yellow image with a viewing angle of greater than 140°. The pixel luminance is typically 90 cd/m^2. The display area is 122 mm high and 195



mm wide, and the whole display assembly, including the drive-electronics board, measures 158.5 mm high, 228.6 mm wide, and only 18.3 mm deep.

A dc/dc converter, which you can use remotely or mount on the back of the assembly, is supplied with the unit; it's connected to the display via a ribbon cable. The converter requires dc inputs of 12 or 15V and 5V, and the display typically consumes 16W. It operates over 0 to 55°C.

Prototypes of the display are available now; production shipments are scheduled to start during the first quarter of 1988. The initial sample price for the MD640.400 is DM 2710, or $1650.

Lohja Corp, Electronic Display Div, Box 46, 02201 Espoo, Finland. Phone 042001. TLX 125023.

Circle No 720

Finlux Inc, 20395 Pacifica Dr, Suite 109, Cupertino, CA 95014. Phone (408) 725-1972.

Circle No 721

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Standard recovery diodes
To 15,000 PRV, to 6A. Standard recovery. 22 off-the-shelf models.

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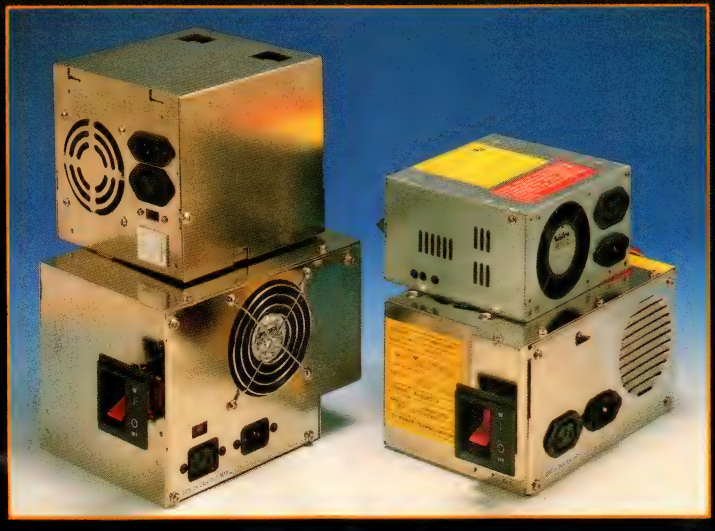

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CIRCLE NO 53

MOTOR CONTROLLERS

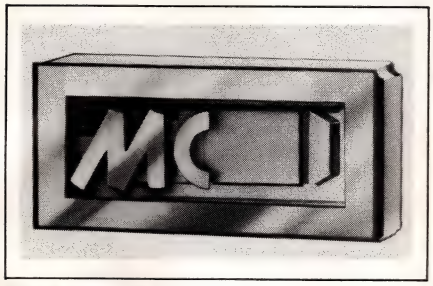
Series 3000 controllers are designed to drive 200 step/revolution stepper motors. Available in versions that control high- or low-voltage motors, the controllers feature an indexer control that makes programming and testing movement commands simple, even for first-time users.

The indexer control lets you generate as many as 200 separate step-motor move profiles, each tailored for starting speeds, acceleration and deceleration rates, running speeds, and distance of moves. To establish the move parameters, you merely set switches on a plug-in Remote Programming Unit and store the parameters in the indexer's nonvolatile EEPROM.

You may choose between a decoded or encoded operating mode, either of which determine the number of move commands stored in the indexer. The decoded mode permits a maximum of eight separate moves; the encoded mode allows 200 moves, the maximum number. In either mode, a single input signal instructs the controller to execute a programmed move. Programmer, $504.90; $1421.28 and $1491.21 (10) for low- and high-voltage controllers, respectively.

Bodine Electric Co, 2500 W Bradley Pl, Chicago, IL 60618. Phone (312) 478-3515. TLX 253646.

Circle No 525



CRYSTALS

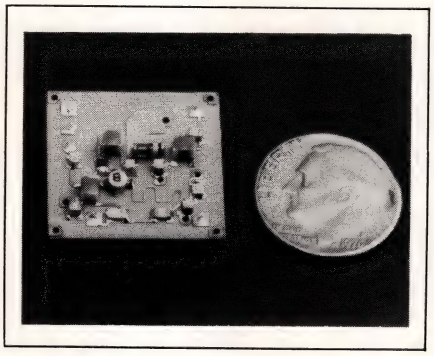
CX-AT-HT high-temperature quartz crystals are designed for surface mounting and provide outputs in the 8- to 24-MHz range. Capable of withstanding vapor-phase, infrared-solder-reflow, or wave-soldering processes, the crystals are available in 16-mm tape on a standard 7-in. reel, with as many as 1000 devices per reel.

The crystals are manufactured by a photolithographic process. Their standard frequencies are 11.592, 12, 16, 20, and 24 MHz. Their frequency tolerance ranges from 50 to 10,000 ppm typ, and their aging spec is 5 ppm for the first year. Industrial units have an operating range that spans −40 to +85°C, and military-grade devices have an operating range from −55 to +125°C.

The crystals meet MIL specs for shock, solderability, terminal strength, vibration, solvent resistance, resistance to soldering heat, fine-leak tests, and thermal shock. $4 to $4.70 (1000).

ETA Industries Inc, 35 E 21st St, New York, NY 10010. Phone (212) 505-5340.

Circle No 526



OSCILLATORS

Model C-500 voltage-controlled oscillators (VCO) feature a 500-MHz tuning range from 950 to 1450 MHz. They have a −90-dBc phase noise specification at 25 kHz offset, −30 dBc harmonics, and a power output of 11 dBm±1 dB.

The VCOs come in two versions. Model C-500A requires 15V dc for power and draws only 30 mA. Tuning voltage to achieve the full 500-MHz tuning range spans 0.5 to 28V dc. Model C-500B requires 12V dc for power and tuning voltage of −12 to +12V dc. Output impedance measures 50Ω.

The oscillators operate over 0 to 70°C with no degradation in performance. They come in 4-pin metal packages that measure 0.8×0.8×0.25 in. $50. Delivery, two to 12 weeks ARO.

Z-Communications Inc, 5450 NW 33rd Ave, Suite 100, Fort Lauderdale, FL 33309. Phone (305) 735-1000.

Circle No 527

LED ARRAYS

These T-1 LED arrays come in single- and dual-row versions for right-angle mounting to pc boards. An additional tab on the bottom of their package improves positioning and alignment during the mounting process.

The units are available in blocks of 1, 2, 4, 8, or 16 LEDs and they have a mounted height of 0.41-in. max. The manufacturer tests the LEDs to ensure uniform light intensity and tins the LEDs' terminals to improve solder-joint reliability.

The arrays are housed in a thermoplastic package and operate from −40 to +85°C. They are available in red, green, and yellow. In the case of the dual-lamp devices, standard combinations are red/red, green/green, yellow/yellow, red/yellow, red/green, and yellow/green. From $0.50.

Elma Electronic Inc, 41440 Christy St, Fremont, CA 94538. Phone (415) 656-3400.

Circle No 528

OPTICAL ENCODERS

HEDS-5500 Series quick-assembly optical incremental encoders are designed for the high-volume digital-encoder market. Mounting and assembling the units on the motor entails only four steps. No follow-up mechanical or electrical adjustments are necessary to activate the encoders, and the mounted encoders are insensitive to radial and axial play.

The encoders contain a highly collimated LED light source and an

integrated circuit with detectors and output circuitry. Due to the detectors' design, the quadrature states of the encoders typically vary by no more than five electrical degrees. The quadrature signal is guaranteed for frequencies to 100 kHz and over a −40 to +100°C operating range.

The encoders are available in nine standard resolutions: 96, 100, 192, 200, 256, 360, 400, 500, and 512 counts per revolution. You can obtain other resolutions by special order. $33 (250).

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 529

MEMBRANE KEYPADS

Series 4000 membrane keypads are available in 3×4 and 4×4 arrays with either embossed-detented or flat nontactile keys. Each keypad features a 5-million-cycle lifetime, sealed splashproof switches, a built-in static shield, and a chemically resistant graphic overlay.

The 4×4 arrays have hexadecimal keypad graphics, whereas the 3×4 units have standard telephone-type keypads. Standard graphics colors are red, black, and white. Configured in an X-Y matrix, the silver switch contacts are mounted on heat-stabilized rigid polyester, which has a 94V-0 UL rating.

The keypads come with 6-in. flex-tail terminations, which include both male and female connectors. From $5.53 (1000). Delivery, four to five weeks ARO.

C&K Components Inc, 15 Riverdale Ave, Newton, MA 02158. Phone (617) 964-6400.

Circle No 530

CONVERTERS

Series 278A300 units are tracking LVDT-to-digital converters. They produce an 11-bit offset binary code as well as an overrange bit. The overrange output warns you that a converter's range limit has been exceeded. After you correct the overrange condition, the unit automatically resets itself.

The 11-bit position-output is accurate to 0.1% of full scale over the 0 to 70°C operating range. The converters accept 2.5V rms inputs and no preamplifiers, trimmers, demodulators, or filters are required.

Packaged in 2.0×2.0×0.38-in. micromodules, the converters rival the size of hybrids yet retain the flexibility and performance of modular converters. $249. Delivery, stock to 10 weeks ARO.

Control Sciences Inc, 9509 Vassar Ave, Chatsworth, CA 91311. Phone (818) 709-5510.

Circle No 531

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CIRCLE NO 19

PROTECTORS

RXE Series Polyswitch circuit protectors are positive temperature coefficient (PTC) resistors that protect electrical circuits against overcurrent conditions. The product line includes units rated to 60V; all devices in the series operate over a −40 to +85°C range.

These units undergo a large, abrupt change in resistance when excessive current or temperature heats them above a specific point. When you correct the fault, the devices cool and reset, allowing normal circuit operation to resume.

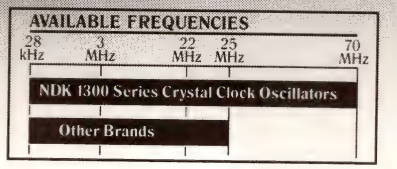
Unlike fuses, these circuit protectors do not require manual resetting or replacement. As a result, consumers cannot defeat them or use incorrect substitutes. The units also offer advantages over circuit breakers, which are prone to vibration-related failures and can prematurely reset and thereby lead to continuous cycling and possible circuit damage. $0.50 (10,000).

Raychem Corp, 300 Constitution Dr, Menlo Park, CA 94025. Phone (415) 361-3333. TLX 348316.

Circle No 532

NDK 1300 Series Compact Crystal Clock Oscillators

NDK's 1300 Series offers the widest range of CMOS- and TTL-compatible compact oscillators available. Frequencies from 28 kHz to 70 MHz with enable/disable std and dual-frequency output as an option. All in rugged, space-saving, half-size packages that are perfect for high density pc-board applications.



NDK 1300 Series Features

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- Low-power/low-heat CMOS technology
- Choice of TTL, CMOS or dual-compatibility
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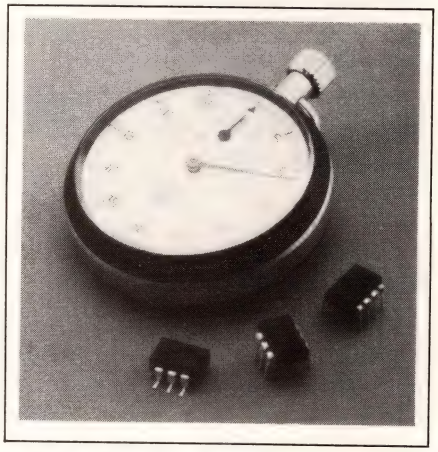
CIRCLE NO 20



RELAYS

The OMA160 is an ac/dc MOSFET-output solid-state relay specifically designed for data-acquisition, instrumentation, and ATE applications. Its internal design optically couples an IR LED with a proprietary photovoltaic IC to control a pair of custom DMOS (double diffused MOS) output chips. This allows the units to drive ac and dc loads directly from CMOS and TTL circuits.

The relays have switching speeds under 100 μsec, which provide switching rates in excess of 5 kHz. Their output capacitance is typically 1 pF, which allows them to control signal frequencies well into the RF range with negligible leakage current.

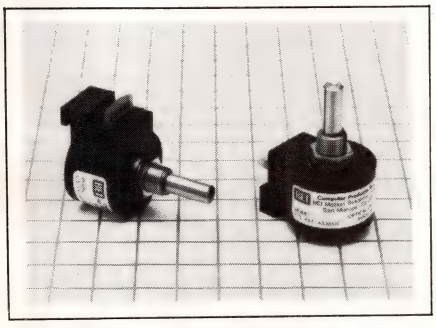
Their ability to switch ac or dc voltages from a few μV to 250V makes the units viable replacements for reed relays, over which they offer advantages in terms of reduced drive power, support circuitry, and pc-board real-estate requirements.

The devices' 6-pin DIP housings

provide industry-standard optocoupler or solid-state relay pin-out compatibility. Lead forming is offered for surface-mount applications. $2.00 (25,000). Delivery, four to six weeks ARO.

Theta-J Corp, 107 Audubon Rd, Wakefield, MA 01880. Phone (617) 246-4000.

533



OPTICAL ENCODERS

PM Series panel-mount optical encoders are designed for applications that require manual control. Interchangeable with analog potentiometers, they provide direct digital accuracy without the need for A/D conversion.

TTL-compatible square-wave signals let you sense relative movements and direction of rotation. The devices come in 1.1×0.7-in. packages and have a resolution of 256 pulses per revolution. You may order an optional index output. Without index output, $24.50; with index output, $34.50 (1000).

BEI Motion Systems Co, 1755 B La Costa Meadows Dr, San Marcos, CA 92069. Phone (619) 471-2600.

Circle No 534

ECL CLOCK

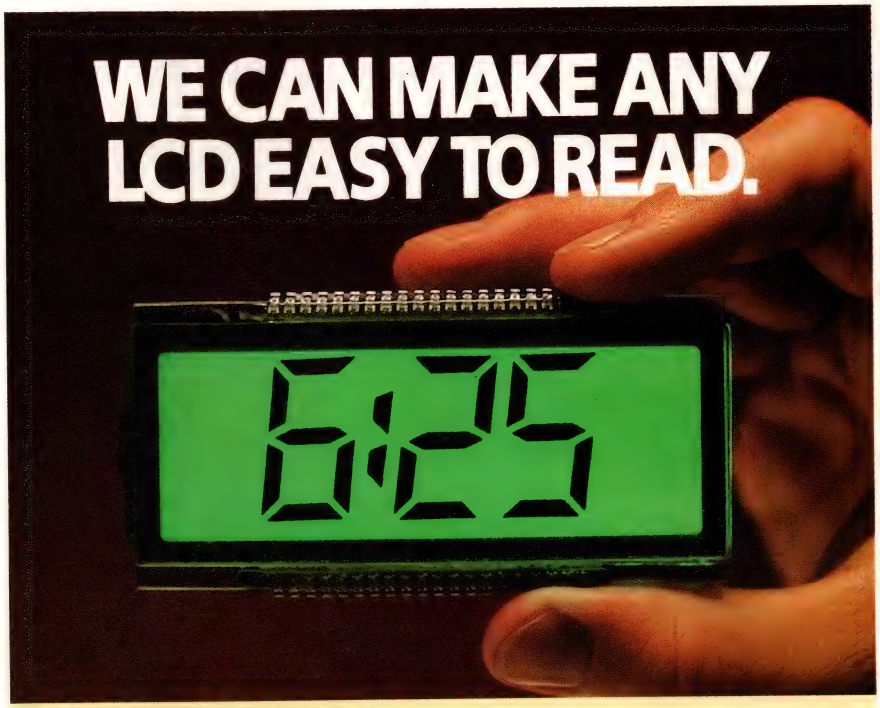
The Model CO-233KEQ ECL clock oscillator provides a stable 100k-type ECL logic output at any specified frequency from 150 to 500 MHz. The standard unit operates from −4.5V dc; −5.2V units are available.

The oscillator output is factory set to within ±0.001% of the specified frequency; units are available with an adjustment that allows you to set the frequency to within ±0.0001%. The standard models provide better than ±0.0025% stability over 0 to 70°C; higher stability and wider operating ranges are available as options.

The oscillator aging rate equals 5 ppm for the first year and 3 ppm per year thereafter. The unit's internal design employs surface-mount components to reduce package size to 1.5×1.5×0.5 in. $275. Delivery, six to 10 weeks ARO.

Vectron Laboratories Inc, 166 Glover Ave, Norwalk, CT 06850. Phone (203) 853-4433. TWX 710-468-3796.

Circle No 541



Our thin, flexible electroluminescent lamps dramatically improve LCD readout by providing higher contrast and better visibility. A thin profile (.032") allows high density packaging, and pressure-sensitive adhesive can be supplied on front or rear surfaces for rapid assembly.

Uniform, cool light source in many shapes, sizes and colors
Our backlighting ELs emit even illumination across the entire lamp surface. They also eliminate the need for sockets, bulbs, diffusers or reflectors. Lamps are usually supplied in rectangular shapes, but we can create many custom shapes and sizes including complex forms with multiple holes and cutouts. With IC-style leads, lamps are compatible with PCB assembly. Eight standard colors are available and custom colors can be created.

If you'd like more information relating to LCD applications, just call, write or TWX the LSI Marketing Department.

Luminescent Systems Inc.
Setting the Standard

Tel. (603) 448-3444 TWX 710-366-0607
Etna Rd., Lebanon, NH 03766

CIRCLE NO 21

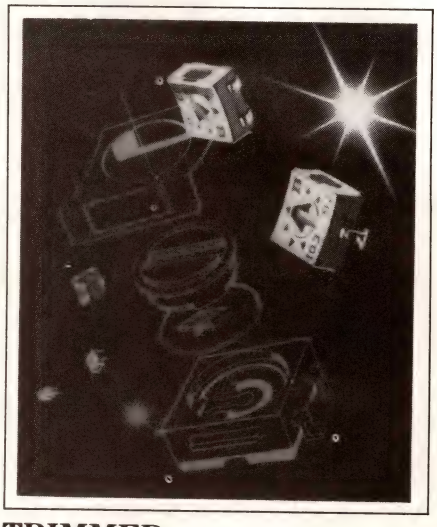
OSCILLATOR

The Model C-1100 frequency source automatically synchronizes its output to periodic or random external inputs and thereby acts as a trigger-coherent timebase. The device is available with a user-specified fixed-frequency output between 850 kHz and 115 MHz.

The oscillator generates its specified output frequency as an ECL-level pulse train with a 20 or 50% duty cycle. The package consists of a delay-line oscillator combined with sychronizing, frequency divider, and interface circuitry for adapting the device for TTL- or ECL-level inputs. The device features ±0.003%/°C frequency stability over the 0 to 50°C operating range. $350.

Berkeley Nucleonics Corp, 1198 Tenth St, Berkeley, CA 94710. Phone (415) 527-1121.

Circle No 535



TRIMMER

The surface-mountable Model 3314 trimming potentiometer is a sealed device that can withstand total solder immersion at 300°C. A plastic body and O-ring construction maintain seal integrity even after processing. The device's 4.45-mm square body and 2.55-mm mounted height minimize pc board real-estate requirements. The package is compatible with all major vacuum pick-and-place equipment.

The standard resistance values for the device range from 10Ω to 2 MΩ and contact resistance variation is 1%. The trimmer is packaged in 12-mm embossed tape on 7-in. reels. $1.09 (1C00). Delivery, 12 weeks ARO.

Bourns Inc, 1200 Columbia Ave, Riverside, CA 92507. Phone (714) 781-5500.

Circle No 536

TRANSFORMERS

PL Series low-profile power transformers feature ratings suitable for triple-output regulated power supplies. The units meet the requirements of European/International standards such as VDE, IEC-65,

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Call or write for information.

ROGERS

Rogers Corporation, Special Products Division
645 West 24th Street, Tempe, AZ 85282 (602) 967-0624

CIRCLE NO 22

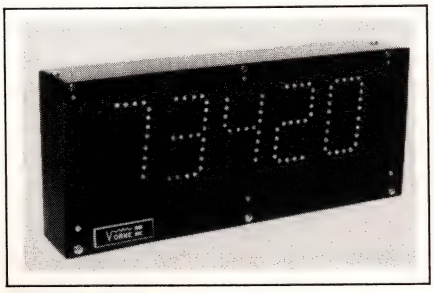
CSA, and UL.

These transformers are primarily intended for μP, control, and instrument applications. Dual nonconcentric bobbins, and an insulating shroud provide high insulation and reduce capacitance. The 130°C insulation system meets UL 94V-0 flammability requirements.

The transformers are available with dual primaries for 115/230V, 50/60 Hz applications. You can obtain regulated outputs of 5 and ±12V dc. $6.87 to $8.77 (250).

Microtran Co, Box 236, Valley Stream, NY 11582. Phone (516) 561-6050.

Circle No 537



DISPLAYS

Model 77/232 serial-input displays provide from two to as many as six 3-in.-high digits. You can use the units in a single stand-alone display application or as one display in a multistation network, even if the displays are thousands of feet apart.

You communicate with the displays via a 2-wire bus that carries either TTL, current-loop, RS-232C, RS-422, or RS-485 signals at a field-selectable rate of 300, 1200, 2400, 4800, or 9600 baud. By using internal DIP switches, you can individually address as many as 98 displays on the bus.

A plug-in board in each display determines the type of serial communication the display uses. For example, an RS-485 transmission can be sent 4000 ft to 32 displays on a common 2-wire bus. $325 to $425.

Vorne Industries Inc, 5831 N Northwest Hwy, Chicago, IL 60631. Phone (312) 775-9440.

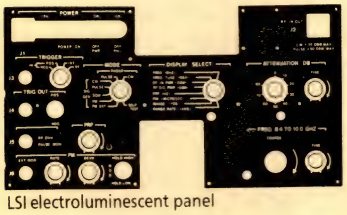
Circle No 538

MOTOR CONTROLLER

The GS-C200 stepper-motor controller module operates with the company's GS-D200 stepper-motor driver to provide complex movement capabilities. Programmed with over 20 high-level movement instructions, the controller can, for example, execute ramp operations, synchronize multiple movements, and provide accurate positioning in either absolute or incremental modes. The control program can include program loops and conditional program execution.

The controller contains an EEPROM for program storage and retrieval, and incorporates an autoload function that boots the required program at power-on. Al-

At only.085" thick, our new fiberglass electroluminescent panels are designed to replace lightplates and traditional metal plates that may not presently be illuminated. Our thin .085" panels weigh 40% less than a typical .220" plexiglass panel, and with an expansion coefficient equal to aluminum, the panels are ideal for surface-mount applications.



LSI electroluminescent panel

As the pioneer developers of EL lamps, as well as the process of encapsulation, we have combined the uniform, cool surface illumination of EL with the strength of fiberglass to create a new standard for panels.

Durability and long life luminescence

LSI EL lamps eliminate the need for sockets, bulbs, diffusers or reflectors, and add no heat to the assembly. This, together with their long life and availability in many colors, make them the intelligent choice for panel illumination – far superior to LEDs or incandescent bulbs. We create panels (including standard .220" plexiglass) in almost any shape and size, as well as complex designs with multiple holes and cutouts. Lamps can be filtered to comply to ANVIS or other military specifications, or to your design requirements.

If you'd like a copy of our brochure, or have questions regarding panel applications, just call, write or TWX the LSI Marketing Department.

Luminescent Systems Inc.
Setting the Standard

Tel. (603) 448-3444 TWX 710-366-0607
Etna Rd., Lebanon, NH 03766

CIRCLE NO 23

ternatively, you can control or download programs to the unit via its RS-232C interface; as many as seven controllers can share the same RS-232C link. Before executing commands, the controller checks them for errors or inconsistencies. In addition to its RS-232C interface, the controller has several TTL-compatible control inputs and outputs.

A built-in switchmode converter allows you to power the controller from a 12 to 40V supply—usually the same supply that you use to power the stepper motor. Development software, which allows you to develop programs for the controller with an IBM-PC or compatible computer, is available. The unit measures 85×60×20 mm. $140 (100).

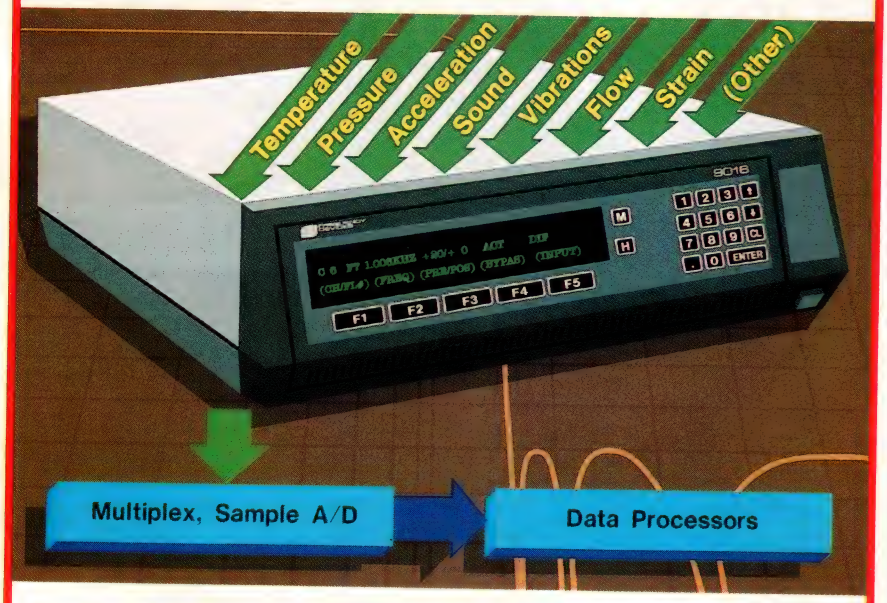
SGS Microelettronica SpA, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 565

SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 566

Multi-Channel Filter for Data Acquisition Systems



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For more information, please call us at **617-374-0761.**

FREQUENCY DEVICES™

CIRCLE NO 24

INTERFACE MODULE

By providing a direct interface between RS-232C and RS-422A serial data links, the NM422AD pc-board mounting interface module lets you convert between RS-232C and RS-422A without having to resort to multirail power supplies or dc-dc converters. The module has sufficient drivers and receivers to provide two full-duplex links. It operates from a single 5V supply and typically consumes 300 mW of power. The unit is housed in a DIP package with a 17×30-mm footprint and a height of 9 mm. The module has an operating temperature range of 0 to 70°C. Around $18 (1000).

Newport Components Ltd, Tanners Drive, Blakelands North, Milton Keynes MK14 5NA, UK. Phone (0908) 615232. TLX 825621.

Circle No 571

SUPPRESSOR CAPS

PMZ2067 Series RFI suppression capacitors can handle voltage transients as high as 8 kV, and they employ a self-healing paper dielectric that can withstand a dV/dt of 2000V/μsec max. They are available with capacitance values in the range of 0.001 to 0.022 μF and have a nominal capacitance tolerance of ±20%. Their voltage rating is 250V ac at 50 Hz, and their recommended dc operating-voltage limit is 1000V dc.

At 1 kHz, the capacitors spec a dissipation factor of 1.3%. Their insulation resistance, measured at 23

°C after 60 sec at 500V dc, is ≥12,000 MΩ.

The capacitors are tested to withstand a dc voltage of 2.7 kV and are subjected to a pulse test using a 10-kV peak, 1.2/50 μsec full wave.

They are suited for use in climatic category IEC-40/100/56 environments and have an operating temperature range of −40 to +100 °C. Depending on their capacitance values, the capacitors are supplied in four case sizes ranging from 13×5.5×13.5 mm to 18×8.5×17 mm. The epoxy resin encapsulation meets the requirements of UL94V-0. Around SEK 6 (10,000).

Rifa AB, 16381 Stockholm, Sweden. Phone 08-757 5000. TLX 8125008.

Circle No 567

Rifa Inc, Box 3110, Greenwich Office, Park 3, Greenwich, CT 06836. Phone (203) 625-7300.

Circle No 568

FIBER TRANSCEIVER

The P35-8858 is a fully integrated fiber-optic transceiver module that operates at data rates of between 20M and 50M bps. It is suitable for use with fiber-optic links as long as 600m in LANs, digital telephone exchanges, or PABX equipment. The module interfaces to the optical fiber via twin expanded-beam fiber-optic connectors incorporated into standard DIN-41612 edge connectors. The module drives the fiber with a high-radiance 850-nm LED. You can order the module in versions for through-hole or surface mounting to a pc board. From $350 (100).

Plessey Optoelectronics Ltd, Wood Burcote Way, Towcester, Northants NN12 7JS, UK. Phone (0327) 51871. TLX 312428.

Circle No 569

Plessey Three-Five Group, 9630 Ridgehaven Court, San Diego, CA 92123. Phone (619) 571-7724. TWX 910-322-1347.

Circle No 570

PLASMA DISPLAY

The APD-256M026, a 256-character dot-matrix plasma-panel display, comes complete with drive electronics and a controller. The unit provides eight 32-character lines, and each 5×7 dot-matrix character measures 0.18×0.26 in. A 5-dot underbar character lets you display a visible cursor.

The unit includes a 4k×8-bit EPROM character generator that's capable of storing two 128-character sets, including 128 ASCII characters and an alternate set of 128 characters. You can program the latter character set. You can also program the display to operate in either serial or parallel mode. $730 (100).

Dale Electronics Inc, Box 609, Columbus, NB 68601. Phone (402) 564-3131.

Circle No 539

DETECTOR

The LHi 1158 pyroelectric detector is a sensor designed specifically for alarm devices that require high reliability. Because it includes redundant detectors, the unit can distinguish between real and false alarms.

Housed in a TO-5 package, the unit comprises two dual-element detectors (lithium tantalate sensors) that have a common supply and ground. The parallel connection provides a high signal-to-noise ratio, whereas the lithium-tantalate sensor ensures long-time stability over a −40 to +70°C operating range. A real alarm condition must generate a signal at both the S_1 and S_2 outputs.

The device has an internal optical filter that permits it to operate over a spectral range of 7 to 14 μm. Its power-supply voltage range spans 3 to 15V dc. $19 (100). Delivery, six to eight weeks ARO.

Siemens Corp, Special Products Div, 186 Wood Ave, Iselin, NJ 08830. Phone (201) 321-3400.

Circle No 544

CIRCLE NO 25

LEDs

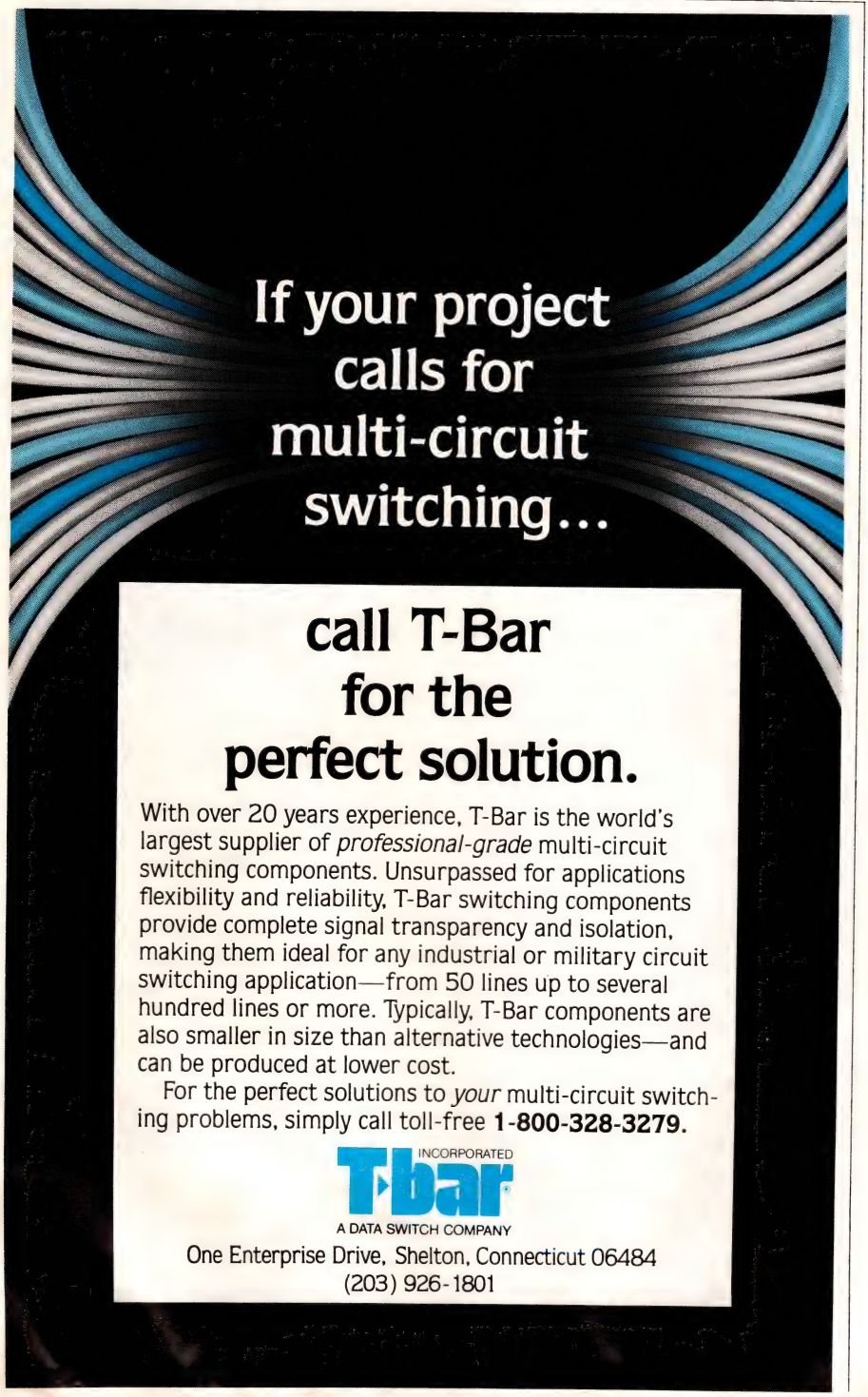
Units in the SLR-37 Series of T-1 LEDs mount flush to the pc board. The LEDs are available in a choice of three lens types—colored-diffused, colored-clear, and transparent (water-clear).

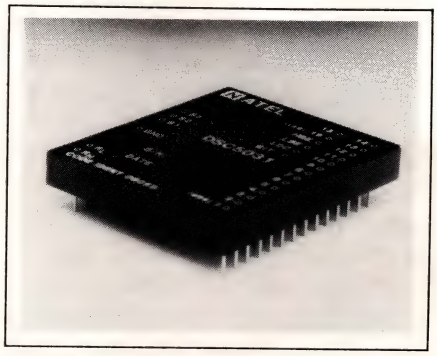
The devices measure 3.1×4.7 mm and have a −55 to +100°C operating range. The viewing angle measures 50° for diffused types and 30° for colored-clear and transparent units. At 10-mA forward current, the typical luminous intensity equals 10 mcd for diffused-lens units and 16 mcd for the clear and transparent types.

These LEDs are packaged for brightness matching and are available in red, high-efficiency red, orange, yellow, and green. $0.15 to $0.35 (1000). Delivery, six to eight weeks ARO.

Rohm Corp, Box 19515, Irvine, CA 92713. Phone (714) 855-2131. TWX 910-595-1721.

Circle No 540





D/S CONVERTER

The DSC5031 16-bit digital-to-synchro converter requires no external power—it generates its internal power from its reference input. Its output is 1.5 VA, accuracy equals 1.3 arc minutes, and radius accuracy is 0.03%. These accuracy specs apply over the full operating temperature, frequency, and load ranges.

The converter is both 8- and 16-bit-μP compatible and is packaged in a 3.1×2.6×0.42-in. module. Its output stage is fully protected and includes fast-acting active-current-limiting circuitry. A built-in test circuit continuously monitors the current in all three output drivers along with other internal test points.

The converter features double buffering on all input-logic data bits. All digital inputs are TTL and 5V-CMOS compatible. From $710. Delivery, six to eight weeks ARO.

Natel Engineering Co Inc, 4550 Runway St, Simi Valley, CA 93063. Phone (805) 581-3950.

Circle No 550

ROTARY SWITCHES

S-400 rotary switches provide from two to as many as 11 positions and offer shorting and nonshorting contacts. BCD contact arrangements are also available. Supplied with

CIRCLE NO 26

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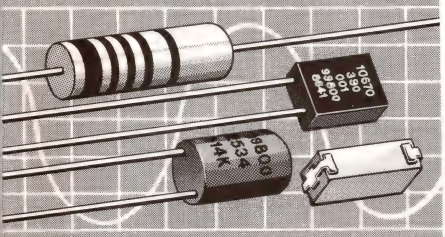

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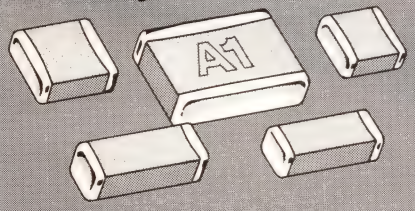

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CIRCLE NO 18

Components

either 8- or 12-pin wafers for pc-board mounting, the switches feature fully enclosed environment-proof bodies that keep dirt, dust, dampness, and flux out of the switch-contact area. The manufacturer claims a 25,000-cycle life.

These rotary switches employ a wear-compensating, dual-ball index construction that provides detent angles of 30, 60, and 90°. The switches are available with a variety of shaft and bushing sizes.

The devices carry 6A and have a make/break rating of 100 mA at 125V ac or 250 mA at 28V dc. Special switch options include molded delrin spacers between decks, and rear bearing and shaft extensions. $8 (OEM qty). Delivery, four to six weeks ARO.

Electroswitch Southern Operations, 2510 North Blvd, Raleigh, NC 27604. Phone (919) 833-0707. TWX 910-240-4611.

Circle No 542

OPTICAL DEVICES

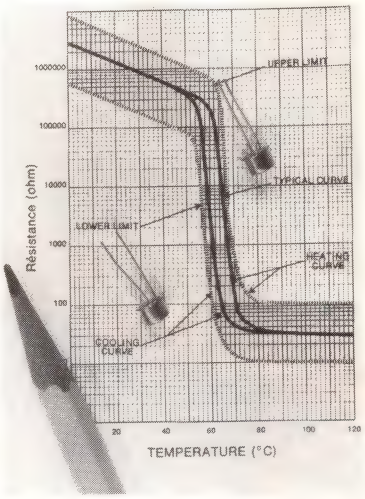
The MLED81 LED and the MRD821 large-area detector are designed for infrared remote control and other sensing applications. The LED supplies a 16 mW typ power output at a 940 nm wavelength. The detector is characterized by a large active area with 50 µA/mW/cm² sensitivity.

The detector is mechanically designed for automated handling and accurate positioning, and it uses an infrared filter to reject visible light. The emitter is housed in a T-1¾ clear epoxy package, whereas the detector comes in a plastic side-looking package. MLED81, $0.59; MRD821, $1.20. Delivery, stock to eight weeks ARO.

Motorola Inc, Semiconductor Products Sector, Box 52073, Phoenix, AZ 85072. Phone (602) 244-3818.

Circle No 543

THINK LOGIC...
SWITCH LOGIC...



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CANTHERM

CIRCLE NO 27

C cross compiler (*Wintek Corp*)

Computer-Aided Engineering

HLL cross compilers speed 1-chip-μC software development

You may be surprised by what today's high-level-language cross compilers have to offer. These advanced software tools can significantly shorten a μC-based product's development cycle, improve code reliability, guarantee programmer portability, and ease software maintenance while imposing minor speed and code-space penalties.

Steven H Leibson, *Regional Editor*

Although most engineers and programmers developing code for μP-based systems have already switched from assembly to high-level languages (HLLs) to reap the benefits of faster coding and better program reliability, the tradition of programming μCs in assembly language still predominates (mostly through inertia). The early μCs' tiny memories and unique architectures mandated the use of assembly language, but you can now take advantage of an increasing number of cross compilers tailored for today's more powerful μC architectures and realize the benefits of HLLs.

Users of μC cross compilers cite speedy development as the primary reason for switching from assembly language. *(Ed Note: In this article, μC cross compilers are simply called compilers for brevity's sake.)* David Wright, a member of General Motors' (Warren, MI) advanced engineering staff, uses Introl's C compiler to develop code for Motorola's 68HC11 μC. Wright and his group build prototype electronic components for potential automotive applications, including antilock-brake and engine controls. He regards C as an excellent language for quickly prototyping experimental systems. If General Motors later decides to develop the prototype into a product, the programmers can rewrite the software in assembly language to reduce code space for the company's extremely high-volume applications. Wright says, however, that the compilers "are close to the point where the memory differential isn't all that great."

Speed the prototyping process

Larry Fish, a development engineer with Comstream Corp (San Diego, CA), uses an Archimedes C-8051 compiler to create code for various μCs based on Intel's 8051 architecture. Comstream, a manufacturer of modems for satellite communications, uses μCs to perform monitoring and control functions. Fish agrees with Wright that μC compilers shorten software development times. Part of the reason for the reduced development cycles is that a compiler allows programmers to think in terms of algorithms instead of in bytes and architectures.

For instance, he says, to perform a 16-bit addition of two numbers on an 8-bit μC using an HLL, you just add the numbers. Using assembly language, you have to first add the lower bytes of the two numbers, save the

Users of μC cross compilers cite speedy development as the primary reason for switching from assembly language.

carry bit, add the two upper bytes together, and then add in the carry. This relatively simple operation requires several lines of assembly language but necessitates only one function in an HLL. Because HLL programs are shorter and easier to write, you achieve both shorter development times and improved code reliability.

Fish wasn't a quick convert to HLL software development for μCs, however. He was apprehensive when he first thought about straying away from the traditional approach of using an assembler. A large project with a tight schedule forced the issue. "You cross your fingers and hope that the tools work," he says. All went well on the first project that used the compiler, and Comstream now develops about 95% of its source code in C. It develops the remainder, mostly low-level I/O drivers, in assembly language.

Not only do compilers reduce development times and enhance code reliability, but they simplify software maintenance later on in a product's life. For example, Fish maintains both the assembly-language programs running in older products and the C programs running in the newer systems. Of the two, he claims maintenance and upgrades are "orders of magnitude easier"

8088 compilers can produce μC code

Many designers use Intel's 8088 (or a derivative such as the company's 80188) in embedded-system designs because of the tremendous amount of software available for that processor architecture. The same HLL cross compilers that generate programs for 8088 μPs can produce code for NEC's (Mountain View, CA) recently introduced 8-bit μPD70322 (V25) and 16-bit μPD70332 (V35) μCs. Both devices execute 8088 object code and incorporate 16k bytes of ROM, 256 bytes of RAM, two full-duplex serial channels, DMA controllers, and parallel I/O ports.

IBM PCs are ideal

IBM PCs and compatibles make ideal development stations for projects employing such devices. Several vendors offer compilers for the PC in just about any language you might wish to use. A few of these, including Manx Software's $499 Aztec C86 commercial system and Datalight's (Bothell, WA) $139 Optimum-C compiler with its $159 ROM-It development kit, support ROM-code generation for embedded systems by allowing you to locate code modules at absolute memory locations.

However, if your PC compiler can't generate ROM code, you may be interested in products that allow you to convert executable files into absolute code. For example, the $95 ROM Kit from Luctor Corp (Phoenix, AZ) will help you put .EXE files into a ROM using one of two techniques.

If your target system will execute its program directly out of ROM, the ROM Kit simply locates your code at an absolute address. However, if you want to gain additional speed by executing your code from RAM, the software package allows you to place executable files in ROM along with a 2k-byte loader program. After a reset, the loader transfers your code to RAM and then starts program execution.

Selectivity is possible

The ROM Kit loader also allows you to place several .EXE files in ROM so that your target system can selectively load and run different programs. Luctor manufactures hard-disk-drive testers and developed the ROM Kit to aid development of its own 80188-based line of testers. The company then decided that other developers might need such a tool and decided to offer its software as a product.

Link & Locate from Systems and Software replaces Microsoft's linker and generates absolute object code from relocatable object modules. The $350 software package includes a cross-reference generator, an object code librarian, a linker, a locator, and hexadecimal formatters that create files in either Intel MCS-86 or Tektronix Tekhex formats.

A variety of PC compilers and assemblers generate object modules compatible with Link & Locate because the Microsoft linker relocatable-object file format is a common denominator for IBM PC software development. The company also offers versions for DEC's VAX, and Sun, Pyramid, Sequent, and Apollo computer systems.

for code developed with HLL programs, whereas tweaking assembly-language programs "is a nightmare every time."

Another major advantage to using HLL compilers is *programmer* portability. If an engineer learns assembly language for one μP or μC, he or she can transfer very little of his new-found knowledge about that processor's assembly language and architecture to an-

Debugging HLL programs on microcomputers

When debugging a high-level-language (HLL) program on a μC, you can choose from three approaches: software simulation, ROM-based debugging, or in-circuit emulation. A software simulator models the μC in software and then interprets your compiled program using that simulation.

The SIM-8051 from Cybernetic Micro Systems (San Gregorio, CA) is an example of such a simulator for the 8051 μC. It works with symbolic files produced by Archimedes' C-8051 compiler. The $595 simulator runs on an IBM PC and displays multiple windows containing source code, register values, memory contents, and a stack image. With such a simulator, you don't need any hardware to try your code, but you must simulate all I/O activity using prepared stimulus files.

If you want to use a ROM-based debugger, Cybernetic Micro Systems offers the dICE-51, a $795 debugger that plugs into your target system and communicates with an IBM PC over a serial link. It includes a preprogrammed 8051 that allows a software simulator running in the PC to perform I/O operations in the target environment. The software running on the PC presents the same user interface as the company's SIM-8051 simulator.

In-circuit emulator *(American Automation)*

If you want to test your code at full speed, however, you'll need an in-circuit emulator. American Automation offers emulators for its μC compilers based on the company's AA545 development station, which costs $4675. In-circuit emulator pods plug into the development station and your target system. Emulator pods for various μCs supported by the company's C compilers cost $2795 to $3995.

Two in-circuit emulators that accept symbolic files from Archimedes' C-8051 and Intel's PL/M-51 compilers are the $1495 EMUL31-PC from Nohau Corp (Campbell, CA) and the MetaIce series of emulators from Metalink (Chandler, AZ). The EMUL31-PC consists of software and two boards: a card that plugs into a PC, and an emulator pod that plugs into your target system. The emulator pod accepts an 8031 or any other 40-pin μC from the 8031 family. Metalink offers emulators for all the μCs based on the 8051 architecture, including Intel's 83C152 communications controller, which incorporates an 8051 core processor. The company's emulators range in price from $1495 to $4995.

Despite all their advantages, HLL compilers don't automatically eliminate the need for an assembler.

other processor. HLL programmers, in contrast, generally can apply a tremendous amount of experience gained on one project to the next because the HLL compiler masks the μC's underlying hardware.

Wright, Fish, and Paula Brown, a marketing manager at Intel's Development Tools Operation, agree. In fact, according to Brown, Intel's customers believe that programmer portability is more important than code portability for μC development work; the architectural diversity of hardware designs that incorporate μCs usually precludes the re-use of software from one project to the next, no matter what language was used to create that software. Most companies certainly want their programmers to be able to write code for a variety of processor architectures, however.

This same sort of portability also allows you to develop software before building any hardware at all. You can develop a prototype on a μP system and then transfer it to a μC using a cross compiler.

Ron Bodle, a consultant working at Daron Associates (Recida, CA), uses Turbo C, a $99.95 compiler from Borland International (Scotts Valley, CA), to develop software for systems containing μPs and μCs. Turbo C is a resident compiler that generates code for the 8088 μP (or one of its descendants) on an IBM PC (see **box,** "8088 compilers can produce μC code"). The object code that Turbo C produces won't run on the target system, but, according to Bodle, the compiler's speed and ease of use enable him to write and debug code very quickly on a PC. He then uses a cross compiler to recompile the same source code for the target μP or μC.

The need for assembly language remains

Despite all these advantages, HLL compilers do not automatically eliminate the need for an assembler. You may need to write time-critical sections of code, including interrupt-service routines and some hardware-specific modules (such as low-level I/O drivers), in assembly language. You should be cognizant, however, that many times even these routines are candidates for HLL coding. Compilers may generate slower code than assemblers, but the difference between compiler-generated and hand-crafted assembly code may not be very great and sometimes no difference in execution speed exists at all.

When shopping for a compiler, you'll want to consider the type of output each compiler generates. If a compiler package includes a linker and creates relocatable object modules, you may be able to avoid the cost of an assembler if you plan to use only the HLL to create your code. You should be aware that linkage formats for these relocatable object modules vary among compiler

TABLE 1—REPRESENTATIVE CROSS COMPILERS FOR 8051 μC

VENDOR	COMPILER	LANGUAGE	HOST CPU	COMPILER OUTPUT	PRICE	ASSEMBLER PRICE	COMMENTS
AMERICAN AUTOMATION	AA554-8051	C	PC	ASSEMBLER SOURCE CODE	$795	$595	COMPANY ALSO OFFERS DEBUGGER AND IN-CIRCUIT EMULATOR
ARCHIMEDES SOFTWARE	C-8051	C	PC, MICROVAX, VAX (VMS, UNIX)	RELOCATABLE OBJECT CODE	$995 TO $5995	INCLUDED	FREE DEMO DISK, BIMONTHLY NEWSLETTER
BOSTON SYSTEMS OFFICE	BSO/PLM 8051	PL/M	PC, VAX, GPX, MICROVAX, VAXSTATION	ASSEMBLER SOURCE CODE	$3750 TO $16,500	INCLUDED	INCLUDES DEBUGGER
INTEL	D86PLM51NL	PL/M	PC	RELOCATABLE OBJECT CODE	$750	$750	COMPANY ALSO OFFERS DEBUGGER/ IN-CIRCUIT EMULATOR
MICRO COMPUTER CONTROL	MICRO/C-51	C	PC	ASSEMBLER SOURCE CODE	$750	$750	MONTHLY NEWSLETTER COVERING CROSS-COMPILER TECHNIQUES
OKAPI SYSTEMS	8051C	C	PC (XENIX), SUN, VAX	ASSEMBLER SOURCE CODE	$3500	INCLUDED	
	8051C	C	PC (MS-DOS)	ASSEMBLER SOURCE CODE	$950	INCLUDED	INCLUDES MKS TOOLKIT OF UNIX-LIKE SOFTWARE TOOLS
SCIENTIFIC ENGINEERING LABS	FLEX51	PASCAL	PC	ASSEMBLER SOURCE CODE	$745	INCLUDED	$35 DEMO DISK

vendors: Frequently you can't intermix modules from different HLL compilers and assemblers.

Exceptions to this situation occur when a vendor, such as Intel or Introl, offers more than one HLL compiler for a μC. Many debugging tools also make use of linkable-object files to obtain symbolic information (see **box,** "Debugging HLL programs on microcomputers"). If you use a symbolic debugger to troubleshoot your μC code, you'll want to make sure that your compiler generates modules that your debugger can use.

Determining the need for an assembler

In addition, some compilers generate assembly-language source files that you then must assemble. Vendors of such compilers may include an assembler for the

TABLE 2—REPRESENTATIVE CROSS COMPILERS FOR 647180 μC

VENDOR	COMPILER	LANGUAGE	HOST CPU	COMPILER OUTPUT	PRICE	ASSEMBLER PRICE	COMMENTS
AMERICAN AUTOMATION	AA554-64180	C	PC	ASSEMBLER SOURCE CODE	$795	$595	COMPANY ALSO OFFERS DEBUGGER AND IN-CIRCUIT EMULATOR; SUPERSTUFF UTILITY HANDLES BANK SWITCHING TRANSPARENTLY
ARCHIMEDES SOFTWARE	C-Z80/64180	C	PC, MICROVAX, VAX (VMS, UNIX)	RELOCATABLE OBJECT MODULES	$995 TO $5995	INCLUDED	FREE DEMO DISK, BIMONTHLY NEWSLETTER
BOSTON SYSTEMS OFFICE	BSO/C	C	VAX, GPX, MICROVAX, VAXSTATION	ASSEMBLER SOURCE CODE	$2000 TO $8500	$1500 TO $6500	COMPANY ALSO OFFERS CROSS DEBUGGER
	BSO/PASCAL	PASCAL	VAX, GPX MICROVAX, VAXSTATION	ASSEMBLER SOURCE CODE	$2000 TO $8500	$1500 TO $6500	COMPANY ALSO OFFERS CROSS DEBUGGER
INTERMETRICS	INTERTOOLS	C	PC, APOLLO, SUN, VAX, VAXSTATION	RELOCATABLE OBJECT MODULES	$1000 TO $5000	$800 TO $4000	COMPANY ALSO OFFERS CROSS DEBUGGER
	INTERTOOLS	PASCAL	APOLLO, SUN, VAX, VAXSTATION	RELOCATABLE OBJECT MODULES	$2500 TO $5000	$2000 TO $4000	COMPANY ALSO OFFERS CROSS DEBUGGER
LATTICE	Z80 COMPILER	C	PC	RELOCATABLE OBJECT MODULES	$500	NOT OFFERED	
MANX SOFTWARE SYSTEMS	AZTEC C CROSS	C	PC, CP/M	ASSEMBLER SOURCE CODE	$349 TO $1250	INCLUDED	INCLUDES 64180 ASSEMBLY-CODE OPTIMIZER
MICROTEC RESEARCH	MCC180	C	PC	ASSEMBLER SOURCE CODE	$1750 TO $6000	INCLUDED	COMPANY OFFERS TRIAL-SIZE DEMO DISKS
	PAS HD64180	PASCAL	PC	ASSEMBLER SOURCE CODE	$1750 TO $6000	INCLUDED	COMPANY OFFERS TRIAL-SIZE DEMO DISKS
SOFTAID	MTBASIC	BASIC	PC, CP/M (NOTE 1)	ABSOLUTE OBJECT CODE	$450	NOT APPLICABLE	LANGUAGE HAS BUILT-IN MULTITASKING. $5500 FOR COMPILER SOURCE
2500AD SOFTWARE	64180 C	C	PC, ZEUS, VAX (UNIX, VMS)	ASSEMBLER SOURCE CODE	$500 TO $2000	INCLUDED	
Z-WORLD	HI-TECH C	C	PC, CP/M (NOTE 1)	ASSEMBLER SOURCE CODE	$195 TO $345	$49.95 TO $195	COMPANY OFFERS RESIDENT DEBUGGER. SEE NOTE 2

NOTES:
1. THE SOFTAID MTBASIC AND THE CP/M VERSION OF THE HI-TECH C COMPILERS REQUIRE CP/M EMULATOR SOFTWARE OR A 64180 CO-PROCESSOR CARD AVAILABLE FROM Z-WORLD TO RUN ON A PC HOST. BOTH COMPILERS WILL ALSO RUN ON ANY CP/M-BASED COMPUTER.
2. AVAILABLE IN AUSTRALIA FROM HI-TECH SOFTWARE, ALDERLY, QUEENSLAND.

If you decide to write your next μC program in an HLL, you'll find several languages to choose from.

TABLE 3—REPRESENTATIVE CROSS COMPILERS FOR 6301, 6801, AND 68HC11 μCs

VENDOR	COMPILER	TARGET μCs	LANGUAGE	HOST CPU	COMPILER OUTPUT	PRICE
AMERICAN AUTOMATION	AA554-6301 AA554-6801 AA554-6811	6301 6801 68HC11	C	PC	ASSEMBLER SOURCE CODE	$795
ARCHIMEDES SOFTWARE	C-6301/6801 C-68HC11	6301/6801 68HC11	C	PC, MICROVAX, VAX (VMS, UNIX)	RELOCATABLE OBJECT MODULES	$995 TO $5995
INTERMETRICS	INTERTOOLS	6801/68HC11	C	PC, APOLLO, SUN, VAX, VAXSTATION	RELOCATABLE OBJECT MODULES	$1000 TO $5000
	INTERTOOLS	6801/68HC11	PASCAL	PC, APOLLO, SUN, VAX, VAXSTATION	RELOCATABLE OBJECT MODULES	$1000 TO $5000
INTROL	C01 C03 C11	6801 6301 68HC11	C	PC, AT&T 3B1, VAX, MICROVAX, CONVERGENT TECH, STRIDE, STRITEK, GOULD POWERNODE	ASSEMBLER SOURCE CODE	$1950 TO $8000
	M2-01 M2-03 M2-11	6801 6301 68HC11	MODULA-2	PC, AT&T 3B1, VAX, MICROVAX, CONVERGENT TECH, STRIDE, STRITEK, GOULD POWERNODE	ASSEMBLER SOURCE CODE	$1950 TO $8000
OKAPI SYSTEMS	6301C	6301/6801	C	PC (XENIX), SUN, VAX	ASSEMBLER SOURCE CODE	$3500
WINTEK	PCC01	6301/6801/68HC11	C	PC	RELOCATABLE OBJECT CODE	$895

TABLE 4—REPRESENTATIVE CROSS COMPILERS FOR OTHER μCs

VENDOR AND TARGET μC	COMPILER	LANGUAGE	HOST CPU	COMPILER OUTPUT	PRICE
ARCHIMEDES SOFTWARE INTEL 8096/80C196	C-8096	C	PC, MICROVAX, VAX (VMS, UNIX)	RELOCATABLE OBJECT MODULES	$995 TO $5995
INTEL	D86C96NL	C	PC	RELOCATABLE OBJECT CODE	$750
	D86PLM96NL	PL/M	PC	RELOCATABLE OBJECT CODE	$750
LATTICE NEC μPD78310/78312	NEC COMPILER	C	PC	RELOCATABLE OBJECT CODE	$1250
MICRO COMPUTER CONTROL ZILOG SUPER8	MICRO/C-S8	C	PC	ASSEMBLER SOURCE CODE	$750
MICRO COMPUTER CONTROL ZILOG Z8	MICRO/C-Z8	C	PC	ASSEMBLER SOURCE CODE	$750
NATIONAL NATIONAL HPC16003/43/83	MOLE-HPC-IBM-C	C	PC	ASSEMBLER SOURCE CODE	$795
SKY COMPUTERS TI 32020	SKYC20	C	PC, SUN, VAX	ASSEMBLER SOURCE CODE	$1500 TO $3500
TEXAS INSTRUMENTS TI 320C25	TMDX3242255	C	PC, VAX	ASSEMBLER SOURCE CODE	$2500 TO $5000

ASSEMBLER PRICE	COMMENTS
$595	ONE ASSEMBLER HANDLES BOTH THE 6301 AND THE 6801 μCs; COMPANY ALSO OFFERS DEBUGGERS AND IN-CIRCUIT EMULATORS
INCLUDED	FREE DEMO DISK, BIMONTHLY NEWSLETTER
$800 TO $4000	SEPARATE VERSIONS AVAILABLE FOR 6801 AND 68HC11; COMPANY ALSO OFFERS CROSS DEBUGGER
$800 TO $4000	SEPARATE VERSIONS AVAILABLE FOR 6801 AND 68HC11; COMPANY ALSO OFFERS CROSS DEBUGGER
INCLUDED	COMPANY PLANS TO RELEASE A DEBUGGER IN JANUARY 1988
INCLUDED	COMPANY PLANS TO RELEASE A DEBUGGER IN JANUARY 1988
INCLUDED	
INCLUDED	

ASSEMBLER PRICE	COMMENTS
INCLUDED	FREE DEMO DISK, BIMONTHLY NEWSLETTER
$750	COMPANY ALSO OFFERS DEBUGGER AND IN-CIRCUIT EMULATOR
$750	COMPANY ALSO OFFERS DEBUGGER AND IN-CIRCUIT EMULATOR
INCLUDED	
$750	
$750	
$495	FREE COMPILER AND ASSEMBLER TRIAL-SIZE DEMO DISKS
INCLUDED	
INCLUDED	COMPANY ALSO OFFERS DEBUGGER AND IN-CIRCUIT EMULATOR

purchase price of the compiler, but some do not. Don't count on an assembler from one company to assemble a source file generated by another company's compiler. If price is your overriding concern, be sure and compare the total cost of a software development system by adding the assembler's cost to that of the compiler if one is not included. **Tables 1, 2, 3,** and **4** list representative HLL cross compilers for several μCs. The **tables** also indicate the type of code each compiler generates and the cost of a companion assembler if one is necessary.

Don't overlook the host computer you plan to use. It also has an effect on the cost of a compiler. As you can see from the **tables,** compilers are available that run on computers ranging from PCs to top-of-the-line VAXs. A compiler's cost tends to track the purchase price of the host computer, so for small projects you may want to stick with the lower-cost, PC-based compilers. For large, multiprogrammer projects, you may find that the compilers running on the larger machines may be more suitable because these machines often provide better environments for software teams.

Compilers for some unconventional μCs appear in the **tables** as well. Engineers usually think of Texas Instruments' 320C20 and 320C25 as DSP processors, for instance, but some designers use the devices in non-DSP applications. According to Elaine Braun-Keller, DSP product manager for Sky Computers, TI's 320 Series can function as excellent high-speed, general-purpose μCs that incorporate a fast multiplier for good measure.

Also, compilers that generate code for the popular Zilog Z80 and Hitachi 64180 μP architectures can now generate code for a μC: Hitachi's HD647180 **(Table 2).** This recently introduced device has 16k bytes of on-chip EPROM. You can find several resident HLL compilers for the Z80 that run on computers using CP/M because of the μP's association with that venerable operating system. You can also use a CP/M emulator like the $99.95 ZSIM program available from Z-World to run these tools as cross compilers on a PC.

If you decide to write your next μC program in an HLL, you'll find several languages to choose from—C, Pascal, PL/M, Modula 2, and even Basic. Programming-language preferences often resemble something of a religious issue with programmers. Certain vendors, including Intel, Intermetrics, and Introl, offer μC compilers for more than one HLL: They've found that language preferences often depend more on personality and programming style than on what each language can

For more information . . .

For more information on the μC development products discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

American Automation
2651 Dow Ave
Tustin, CA 92680
(714) 731-1661
TWX 910-595-2670
Circle No 681

Archimedes Software Inc
1728 Union St
San Francisco, CA 94123
(415) 771-3303
TWX 650-287-5314
Circle No 682

Boston Systems Office Inc
128 Technology Ctr
Waltham, MA 02254
(617) 894-7800
TWX 710-324-0760
Circle No 683

Intel Corp
Box 58065
Santa Clara, CA 95052
(916) 351-6289
Circle No 684

Intermetrics Inc
Software Products Div
733 Concord Ave
Cambridge, MA 02138
(617) 661-0072
TWX 710-320-7523
Circle No 685

Introl Corp
647 W Virginia St
Milwaukee, WI 53204
(414) 276-2937
Circle No 686

Lattice Inc
2500 S Highland Ave
Lombard, IL 60148
(312) 916-1600
TLX 532253
Circle No 687

Manx Software Systems Inc
Box 55
Shrewsbury, NJ 07701
(201) 542-2121
TLX 4885812
Circle No 688

Micro Computer Control Corp
Box 275
Hopewell, NJ 08525
(609) 466-1751
TWX 910-240-4881
Circle No 689

Microtec Research
Box 60337
Sunnyvale, CA 94088
(408) 733-2919
Circle No 690

National Semiconductor Corp
Box 58090
Santa Clara, CA 95052
(408) 721-5000
TLX 346353
Circle No 691

Nohau Corp
51 E Campbell Ave
Campbell, CA 95008
(408) 866-1820
Circle No 692

Okapi Systems Inc
Box 3095
Everett, WA 98203
(206) 258-1163
Circle No 693

Scientific Engineering Laboratories
255 Beacon St, Suite 3D
Somerville, MA 02143
(617) 625-0288
Circle No 694

Sky Computers Inc
Foot of John St
Lowell, MA 01852
(617) 454-6200
TLX 4991331
Circle No 695

Softaid
8930 Rte 108
Columbia, MD 21045
(301) 964-8455
Circle No 696

Texas Instruments Inc
Semiconductor Group (SC-740)
Box 809066
Dallas, TX 75380
(800) 232-3200
TLX 73324
Circle No 697

2500AD Software Inc
17200 E Ohio Dr
Aurora, CO 80017
(303) 369-5001
Circle No 698

Wintek Corp
1801 South St
Lafayette, IN 47904
(317) 742-8428
TLX 709079
Circle No 699

Z-World
1722A Picasso Ave
Davis, CA 95616
(916) 753-3722
Circle No 700

do; HLLs exhibit similar abilities to perform most tasks.

You should consider more objective factors when selecting a language, however. Such factors include the following: the availability of a compiler for the host system you plan to use during code development; the size of the programs you plan to write; the number of programmers working on the project; the efficient utilization of critical on-chip memory by a particular compiler; and how effectively a compiler and its libraries support a μC's unique features. Many μCs have special hardware components such as UARTs, the 8051's multiple memory maps, or the A/D converters found in Intel's 8096 and Motorola's 68HC11, and some compilers explicitly support these features through language extension.

Many compiler data sheets don't discuss these contributing factors, and you may have to dig a bit deeper to find answers. One approach to discovering the efficiency and utility of the compiler in question is to ask a vendor for references. Most companies have customers who are willing to speak with you and can provide far more insight into the capabilities of the software than can a data sheet.

In addition, some vendors will compile a short program for you to illustrate the type of code a particular compiler generates. American Automation offers such a service that it calls Telebench. If you send the company a disk containing source code, it will return the disk with a compiled version of your program and tell you how much time the compilation required.

You can also order demonstration disks containing "trial-size" compilers from several companies. The compilers on these disks can generate small programs so you can examine how they work. For example, National offers free C-compiler and assembler disks for its HPC series of μCs. The company has put a software "governor" on the compiler so that it accepts only about 1000 lines of source code, and generates no more than 3k bytes of code and another 3k bytes of data. Considering that the HPC16043 and HPC16083 μCs incorporate respective 4k- and 8k-byte ROMs, you can write substantial programs with these free software packages.

EDN

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3. Terry, Chris, "Cross-development tools for PCs and minis let you develop software for 8-bit μPs," *EDN*, April 15, 1987, pg 89.
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Windowed operating environment for CAE spans a variety of computer systems

The Vanguard Stellar CAE design system integrates a complete CAE tool set in a graphical shell that provides a windowed operating environment. This environment allows for complete design-file compatibility among the various tools, which include a schematic-design system, a symbol editor, a layout editor, an autorouter, a design-rule checker, an electrical-rule checker, analog and digital simulators, and a document editor.

The Stellar system works on many computers, but operation is identical. Once you've learned how to use the system on an IBM PC/AT, you'll know how to use it on a Sun/3, a VAX, or a Microvax II GPX workstation. To communicate with other vendors' simulation tools, the Stellar system uses the CSDF (Common Simulation Data Format) for data transfer. At present, the system can communicate with Silos, Cadat, PSpice, Spice, and Hilo.

The ASCII database resides at the core of the system. Each of the tools works with and creates ASCII files, so you can transfer data among tools. For example, you can transfer a section of a schematic to a document, or you can tell a simulator which node in a circuit you would like to view.

The document editor provides simple mixed text-and-graphics capability for engineering documentation, and it supplies interfaces to desktop-publishing packages. Having direct access to such documents as schematics, pc-board layouts, and simulation results simplifies the creation of high-quality documentation.

Commands are very similar from one tool to the next. It's not necessary for you to relearn the use of each tool as you progress in the design cycle. Also, each tool has a simple 7-command mode that allows you to tackle many tasks without having to master the full complexity of the system. Prices range from $15,900 for a PC/AT-based system to $50,000 for a VAX-based system.

Case Technology Inc, 2141 Landings Dr, Mountain View, CA 94043. Phone (415) 962-1440. TLX 506513.

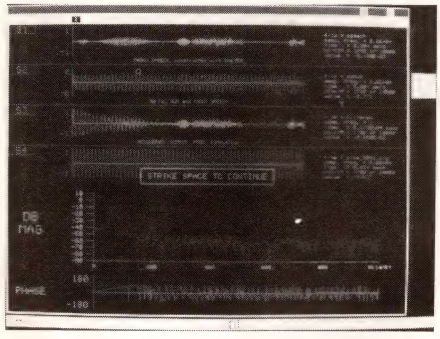
Circle No 677

Advanced-CAE tool set aids in design and simulation of DSP systems

The Signal Processing Worksystem (SPW), a set of tools for designing and simulating a DSP system, runs on either VAXstation computers under VMS or on Apollo Domain workstations.

The Designer's Database Schematic Capture (DDSC) tool provides menu-driven facilities for capturing a design in the form of hierarchical blocks and analyzing their operation and interaction. You can generate a net list from your graphical design representation.

The Simulation Program Builder (SPB) converts the DDSC block schematic to a program that simulates the behavior of the DSP system. The SPB builds a sequence of procedure calls representing the mathematical function that each



block is to perform. The initialization phase sets the initial conditions for each block; the run phase executes the mathematical operations representing each block in the sequence determined by the block schematic; and the termination phase provides output information about the state of each block.

The Signal Display Editor (SDE) can display as many as 40 signals; it automatically scales each signal to fit the display window. The SDE allows you to generate various signal waveforms and provides the means to analyze a simulation run.

The Instrument Interface Library (IIL) lets you acquire data or control instruments in real time via an IEEE-488 interface. It supports the vendor's 11401 high-speed digitizing oscilloscope and selected TM5000 modular instruments; you can build your own blocks, however. The starting price of the SPW (software only) is $30,000.

Tektronix Inc, CAE Systems Div, Box 4600, M/S 94-525, Beaverton, OR 97076. Phone (503) 629-1255. FAX (503) 645-8067.

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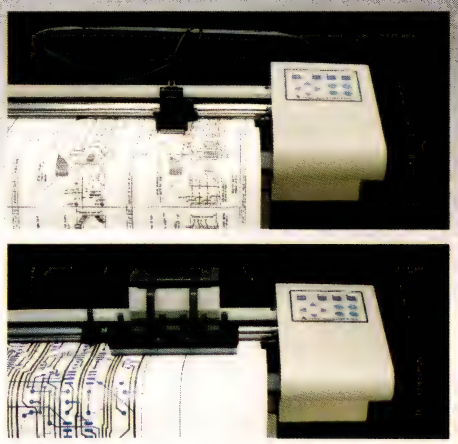

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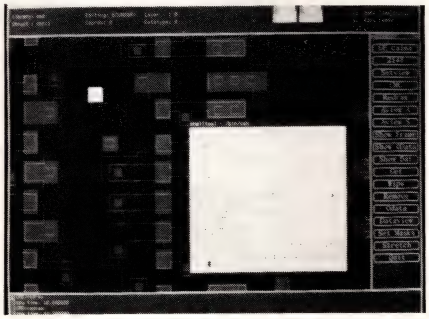
CIRCLE NO 55

System for CAE design management runs on network of workstations

EDS III is an IC-design system that consists of a graphics editor and a block manager. It is fully compatible with the vendor's GDS II system, and it includes a communications link that connects GDS II systems running on Data General computers with EDS III systems. The link uses the TCP/IP network protocol. EDS III currently runs on Sun workstations and will be available for DEC and Apollo machines in the first quarter of 1988.

Each network node provides a name server that records the names of users and files resident on that node, and communicates those names to users on other nodes. A library administrator determines the location of a library requested by a user and makes it accessible. Compared with GDS II's database, EDS III's database uses less disk



space and provides faster access to data. New routines let you extract data for processing by other applications.

The graphics editor is written in C, and the graphics portion is isolated to achieve portability without sacrificing speed. You can enter any command directly from the keyboard, or you can use the extensive menu system. You can configure the menus to suit your application; change the command names; or assign new command names to simple functions, macros, or command files that will execute complex command sequences.

The block-manager module lets you fix the location of blocks and standard cells via manual or automatic placement or a combination of both. The automatic-placement routines accept specific design rules, which you create with an interactive editor. You can also create a file of generic design rules that the editor will automatically map into specific rules. There are no restrictions on the placement of blocks, or on how you attach power and ground to the blocks. Editor, $20,000; block manager, $50,000.

GE Calma Co, 501 Sycamore Dr, Milpitas, CA 95035. Phone (408) 434-4000. TLX 3720067.

Circle No 678

CAE network node features both digital- and analog-simulation capabilities

The Configurable Analysis Engine is a network server that provides a network of IBM PC/ATs (or compatibles) with resources for digital and analog simulation, accelerated schematic compilation, physical modeling, and CAE database management. The basic unit consists of a 68020 μP, 4M bytes of RAM, 80M bytes of mass storage, an Ethernet interface, and software for schematic compilation and either accelerated analog simulation or nonaccelerated digital simulation.

For accelerated digital simulation, you need the bit-slice processor option; this processor uses an 88-bit microcode word and has a machine cycle time of 55 nsec. It can

run digital simulations 30 to 50 times as fast as the 68020 system processor.

For accelerated compilation and accelerated analog simulation, you need to add one or more general-purpose RISC (reduced-instruction-set-computer) processors. You can use as many as four of these processors for Monte Carlo analysis and other computation-intensive applications.

The physical-modeling section uses one or two VLSI stimulus cards and a maximum of five VLSI carrier cards; the modeler can exercise chips at rates as high as 16 MHz. You can also add as much as 65M bytes of dual-port RAM for large modeling applications. The price of a basic unit starts at $30,900.

Cadnetix Corp, 5757 Central Ave, Boulder, CO 80301. Phone (303) 444-8075.

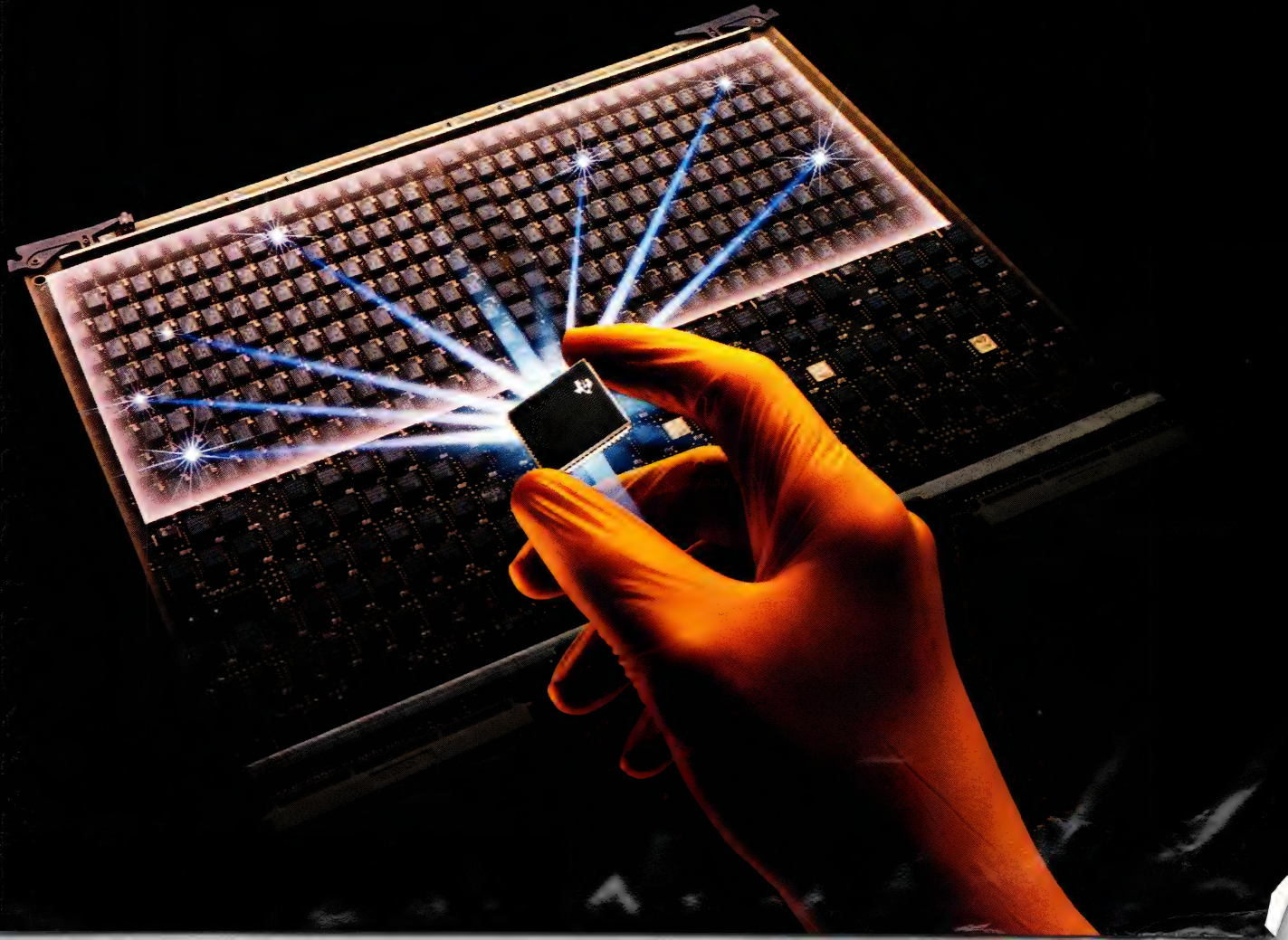
Circle No 679

TEXAS INSTRUMENTS REPORTS ON

MEMORY MANAGEMENT

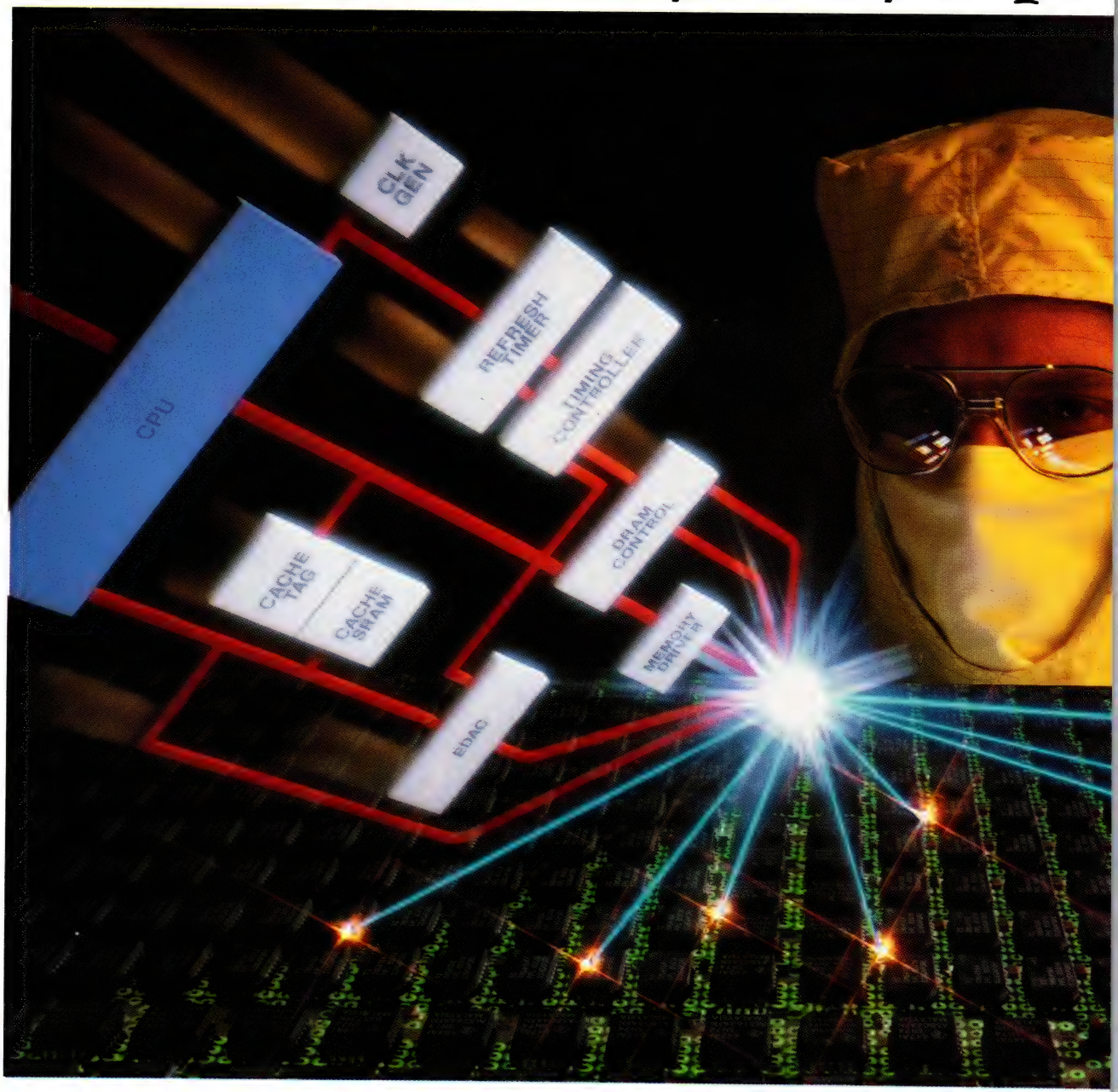
IN THE ERA OF

MegaChip TECHNOLOGIES



Memory management in the Era of MegaChip Technologies:

Memory-management ICs fro
you bring memory arrays up t



Memory systems are a prime area for significant improvements in overall system throughput. Read how TI's memory-management ICs can get you in and out of memory faster no matter which processor you choose.

You can now solve a problen whose solution has eluded design e neers for years: How to catch mem speeds up to CPU speeds. The solu lies with TI's advanced memory-management circuits, and you can them with whichever processor bes suits your application.

Texas Instruments can help processor speeds.

A universal architecture enables
ese TI devices to work with — and
hance — virtually any high-speed
icroprocessor or bus structure, even
stom engines.

In addition, your component count
cut because these are single-chip
LSI circuits. Your design time and
fort are shorter and easier because of

TI's comprehensive Memory Management Design Kit *(see page 4)*.

TI addresses your major memory-design concerns

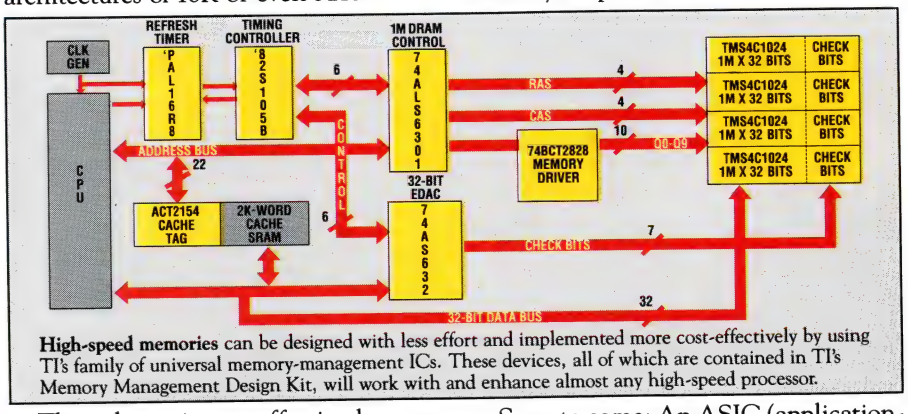
To immediately improve memory-access time, use both main and cache memories, as shown in the block diagram. This approach can produce up to a 3X increase in system performance.

Frequently accessed data and instructions are stored in a few high-speed static random-access memories and "tagged" by a TI industry-standard cache controller (SN74ACT2151/4). These CMOS controllers are the fastest available and can support deep cache architectures of 16K or even 32K.

TI's MegaChip Technologies

Our emphasis on volume manufacturing of high-density circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers. These are our MegaChip™ Technologies. They are the means by which we can help you and your company get to market faster with better, more competitive products.

tions on chip to improve flexibility and speed and to allow for custom timing routines. This controller supports nibble- and page-mode access and scrubbing-mode refresh to increase memory output.



High-speed memories can be designed with less effort and implemented more cost-effectively by using TI's family of universal memory-management ICs. These devices, all of which are contained in TI's Memory Management Design Kit, will work with and enhance almost any high-speed processor.

This scheme is cost-effective because slower, less expensive dynamic random-access memories (DRAMs) can be used for main memory.

When you must assure system integrity, use of an error-detection-and-correction (EDAC) circuit can improve system reliability 500-fold. Since this approach is necessary with memory arrays larger than half a million bits, TI offers its leadership 32-bit EDAC.

The SN74AS632 detects dual-bit errors and detects and corrects single-bit errors while avoiding processor wait states. It is the fastest EDAC available: 25 ns for error detect, 32 ns for correct.

Interfacing between processor and main memory gets tougher as speeds increase. But TI has the SN74ALS6301 DRAM timing controller. It can handle any DRAM up to 1 Mbit and incorporates only the essential func-

Soon to come: An ASIC (application-specific integrated circuit) solution.

Reducing over/undershoot is accomplished by TI's 2000 Series buffers and drivers — 25-ohm series-damping resistors on the output prevent false reads at DRAM input. For example, the SN74BCT2828 driver can reduce undershoot by 40% compared to traditional approaches. TI's 2000 Series has a high-drive current suitable for VME and MULTIBUS® II bus structures.

You can use any or all of TI's memory-management ICs to obtain the superior performance that marks a market winner. And there's no design rule that says your memory-management chips and your CPU have to come from the same supplier.

▶ *Turn page for more information.*

The tools you need to design a high-performance memory-management system are between these covers:

At $149, the value of TI's Design Kit far outweighs its cost. In one compact file, we've included just about everything you'll need to bring your memory array up to speed. Everything, that is, except your imagination in creating your own unique product differentiators. Here's what you get:

- All necessary high-performance ICs, including
  - —SN74ACT2154 2K X 8 Cache Address Comparator
  - —SN74AS632 32-bit EDAC
  - —SN74ALS6301 16K to 1 Mbit DRAM Controller
  - —SN74BCT2828 10-bit Buffer/Driver with series-damping resistor
  - —TIBPAL16R8-10 and TIB82S105B High-speed Programmable-logic Devices for user-defined timing control
  - —TMS4464 256K DRAM
- *Memory Management Applications Handbook* containing applications reports and briefs that supply valuable insights into memory-management system design.
- Data sheets on TI circuits designed for efficient memory management.
- Memory-management-product software graphic-symbol libraries and supporting documentation for use with Futurenet™ or Mentor Graphics™ CAE systems.

For more information on TI's Memory Management Design Kit, call 1-800-232-3200, ext. 3203, or contact your nearest TI field sales office or authorized distributor.

SDV063ED800C

Texas Instruments Incorporated
P.O. Box 809066
Dallas, Texas 75380-9066

YES, please send me more details on TI's universal memory-management ICs.

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TEXAS INSTRUMENTS

DSP DESIGN TOOL

The DSPlay software package runs on an IBM PC or compatible computer that's equipped with at least 256k bytes of RAM and a CGA or equivalent color-graphics board. The software can use (but does not require) an 8087 or 80287 math coprocessor. Screen menus let you create functional block diagrams (called FlowGrams) and define the processing that each block will perform. The menus, pullup lists, and context-sensitive help windows make it easy to enter, edit, and run DSP algorithms. Once you've developed a FlowGram, you can save any or all of the blocks for future use, and then execute the program.

When debugging, you can execute a single block or execute the program only as far as a selected point. After making changes, you can continue execution from a selected point. The software lets you generate test waveforms for your design. These waveforms include sine and cosine waves; white or Gaussian noise; and triangular, square, or trapezoidal pulses. You can process these signals with routines that perform Fourier transforms, correlations, or convolutions, as well as standard arithmetic and trigonometric functions. The programs perform all calculations in floating-point format with a 40-bit mantissa and an 8-bit exponent. The software can also work with the vendor's A/D- and D/A-converter boards. DSPlay design package, $495; DSP Educational Package, $25.

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 393

PLD DESIGN TOOL

FutureDesigner is a menu-driven program that integrates schematic capture, behavioral logic specification, interactive design verification, and logic synthesis. During entry, you can describe each part of your circuit in the terms best suited to it; that is, you can describe it by means of hierarchical schematics, state diagrams, logic equations, or truth tables. During interactive verification, the program detects and helps you correct connectivity errors and other common design errors. It performs automatic logic synthesis, which optimizes the performance of the design by means of logic reduction and factoring that eliminates redundant circuitry.

You can simulate your design's performance with the help of the vendor's Dash-CADAT Plus logic simulator. The program can partition behavioral descriptions into multiple PLDs; you specify which outputs are to be assigned to which devices, and the program automatically assigns the inputs accordingly. It generates both a schematic for the gate-array vendor and JEDEC output files for programming PLDs. The program runs on IBM PC/ATs and compatibles, and the price includes a 32-bit coprocessor with 2M bytes of onboard RAM. $11,500.

FutureNet, 9310 Topanga Canyon Blvd, Chatsworth, CA 91311. Phone (818) 700-0691. TWX 910-494-2681.

Circle No 394

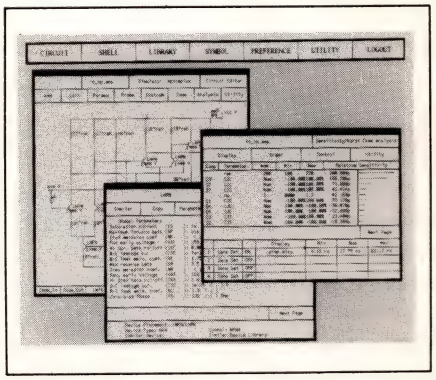
LOGIC DESIGN TOOL

Scratchpad combines a schematic-capture editor and an interactive logic simulator. It runs on an IBM PC, PC/XT, PC/AT, or compatible. The package provides libraries of standard TTL- and high-speed CMOS-logic ICs, including one-shots. The program lets you design a complete schematic in step-by-step fashion, and it automatically checks for drafting and design errors.

As you complete each section of your design, an incremental compiler compiles the section and a high-speed, interactive simulator verifies it. You can select either a timing display, which shows all the signals (including glitches), or a functional display, which shows only the glitches' functional effects. If the simulator detects no errors, you can convert the section into a module or software macro and store it for use in future designs. The package includes interfaces for transferring any module or complete design to other CAE programs for board layout and other processing. $2950.

Aldec, 3525 Old Conejo Rd, Suite 111, Newbury Park, CA 91320. Phone (805) 499-6867.

Circle No 395



IC DESIGN TOOL

Working in conjunction with the vendor's Analog Workbench or PC Workbench software, the IC Design Tool Kit analyzes the linear characteristics of analog designs. It analyzes designs for linear ICs, mixed-signal ICs, digital ICs, or any combination of these types. The program lets you enter fabrication-process parameters, so that the simulator can account for parasitic elements and variations inherent in the selected fabrication process. You can assign either nominal values or distribution ranges to the entered parameters.

The package includes bipolar and CMOS device models of transistors, capacitors, and resistors. You can also create custom models that contain your own process parameters, and then store the models in a private library. You can use Monte Carlo techniques, evaluate a circuit's sensitivity, and estimate worst-case conditions to calculate the manufacturing yield before you commit your design to silicon. The

Smoke Alarm feature lets you analyze the stress levels in your design to improve device reliability. The IC Design Tool Kit costs $13,500 as an option to Analog Workbench, which runs on Apollo, Sun, and HP workstations; it costs $8000 as an option to PC Workbench, which runs on the IBM PC/AT or compatibles.

Analog Design Tools Inc, 1080 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 737-7300.

Circle No 396

IC DESIGN TOOL

ValidCompose is the first tool in the vendor's product line to be entirely driven by design rules. It runs on Sun 3 workstations and on DEC's VAXstation. You begin the design process by creating a functional schematic in which the cells to be used appear as boxes that define the cells' relative shapes and sizes and their connection points. You then use the program's editing features to optimize the cell placement. To minimize wire lengths, the program performs automatic pair and port swapping, as well as automatic rotation and mirroring of cells. It also provides both automatic and interactive routing.

The program performs placement and routing according to design rules that you specify, by means of the editor, on the original schematic. You can identify critical paths and specify wider individual wires than the design rules call for. During floor planning, the program groups cells with critical interconnections and alerts you to the occurrence of critical paths that are too long. Once the program has performed the initial cell placement, it automatically compacts the chip into the smallest possible space, while observing the design rules. $20,000.

Valid Logic Systems, 2820 Orchard Parkway, San Jose, CA 95134. Phone (408) 432-9400. TLX 3719004.

Circle No 397

CAE SOFTWARE

Hiwire is a schematic drawing package that runs on the IBM PC and compatibles. Enhancements include two libraries for ECL components and ladder diagrams, and PostScript output for laser printers. The menu-driven program lets you create library symbols by combining labels, lines, and arcs. You can use a plotter, dot-matrix printer, or laser printer to print a complete schematic diagram. The program can also create a net list and a bill of materials, and it provides cross-checking utilities.

Smartwork is a pc-board design package that accepts net lists created by Hiwire and that helps you generate artwork for the board. Once you have placed all the components, the autorouter finishes the routing process. The vendor has removed the copy protection from the backup diskette, so that you can now install Smartwork on a hard disk. Hiwire and Smartwork, $895 each.

Wintek Corp, 1801 South St, Lafayette, IN 47904. Phone (317) 742-8428. TLX 709079.

Circle No 398

3-D MODELING SOFTWARE

Generic 3-D is a polygon-based 3-D solid-modeling program with a wireframe display. It features a 3-D cursor, and it has perspective, extrusion, isometric-view, construction-plane, multiple-window, automatic-sectioning, interference-checking, object- or group-duplication, and surfaces-of-revolution features. You can use the program as a stand-alone package, or you can transfer your models to Generic CADD and other of the vendor's products. Also available is the add-on 3-D Rendering Module, which defines a solid object by means of its boundaries—faces, vertices, and edges. Generic 3-D, $199.95; 3-D Rendering Module, $149.95.

Generic Software Inc, 8763 148th Ave NE, Redmond, WA 98052. Phone (206) 885-5307.

Circle No 399

SIMULATION MODEL

The Am29000 SmartModel is a simulation model of the Am29000 32-bit μP from Advanced Micro Devices (Sunnyvale, CA). It lets you perform simulations that verify both hardware and software designs. The model lets you check for violations of timing requirements (such as setup and hold times, or minimum pulse widths), and also analyzes usage conditions such as I/O protocols and initialization parameters. Whenever the model detects an error condition, it supplies a detailed error message that allows you to pinpoint the location and nature of the problem. The model is currently available for use on Mentor Graphics systems, and versions for other systems are in development. $6900.

Logic Automation Inc, 19500 NW Gibbs Dr, Beaverton, OR 97005. Phone (503) 690-6900.

Circle No 401

TEST GENERATOR

The automatic test-generator program Anvil ATG runs on IBM PC/XTs, PC/ATs, or on any compatible with 640k bytes of RAM and a hard disk with 4M bytes of available storage. The package furnishes an event-driven, time-based simulator, a concurrent fault simulator, a general-purpose automatic test-vector generator, and utility programs.

"CASE and DEC combine... to offer CAE solutions that work!"

digital

CASE Technology's new Vanguard CAE Design System, in combination with Digital's VAX-based engineering workstations, provides one of the most complete computer-aided engineering solutions available. The system includes schematic capture for PCB and ASIC design, digital logic simulation, circuit simulation and PCB design capabilities.

The strength of the Vanguard CAE design solution is its flexibility. With DECNet and DECNet/DOS, using VAX minicomputers and workstations linked with standard personal computers, an entire engineering facility can be networked, creating a completely integrated design automation environment.

The Vanguard system can also be utilized as a front-end CAE design tool for users that need to integrate existing tools or as a facility solution for those interested in a single source for their CAE needs.

With more than 3000 installed systems worldwide, CASE Technology has developed a solid reputation as a premier supplier of professional CAE design tools. If you haven't seen what CASE has to offer, then now is the time.

CASE Technology Inc., 2141 Landings Drive, Mountain View, California 94043
Phone (415) 962-1440; Telex 506513;
Fax (415) 962-1466

CASE TECHNOLOGY

"CAE Solutions Planned *Right* from the Start"

CIRCLE NO 112

The software is menu-driven, but you can bypass the menus if you want a series of jobs to run in batch mode without operator attention.

According to the vendor, the program typically achieves 90 to 100% fault detection, even on highly sequential designs, such as state machines. The faults considered include stuck-at-0 and stuck-at-1 logic elements and incomplete or improperly blown fuses. So as not to obscure true-fault coverage, the program removes from consideration undetectable faults that derive from redundancy or unused circuitry. $4950.

Anvil Software, 369 Massachusetts Ave, Suite 192, Arlington, MA 02174. Phone (617) 641-3861.

Circle No 400

PARTS LISTER

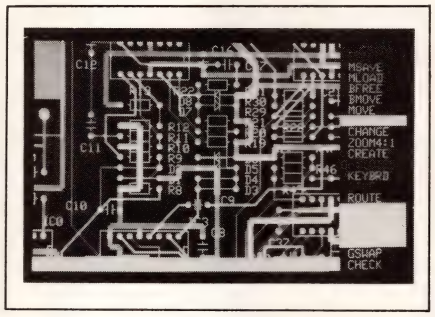
The Enhanced Part List Utility is a software package that lets you build either a simple parts list, showing quantity, part name, and location designator of each part, or a customized list with additional information supplied by the operator. The area-translator utility can format the parts-list output files (or any ASCII file) into a FutureNet area file that you can load directly into a FutureNet Dash schematic. The program runs on IBM PCs and compatibles, and costs $95; registered users of earlier versions can upgrade to the Enhanced version for $45.

CAE Utilities, 14819 Sherman Way, Suite 8, Van Nuys, CA 91405. Phone (818) 989-3308.

Circle No 402

SCHEMATIC CAPTURE

EE Designer version 1.7 is a PC-based software package for schematic capture, logic simulation, pc-board design, and artwork generation. This version is enhanced by a new graphics kernel that lets you define trace widths, pad sizes, and D-code settings for

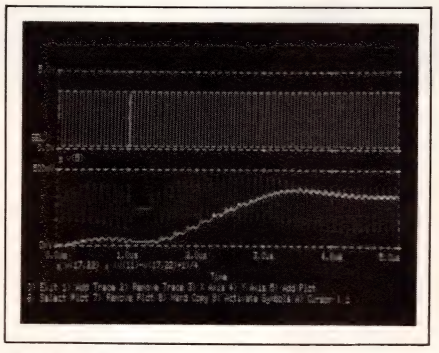


Gerber photoplotting. The router now offers orthogonal-snap and double-snap modes for improved schematic routing.

The package contains a new symbol library with corresponding cross-reference files. In addition, the plot-file feature lets you write your own device drivers so that you can generate prototype-quality artwork on an Epson-compatible, dot-matrix printer. You can also direct output to pen plotters, photoplotters, NC drill tapes, and laser printers that can use the HPGL graphics language. $995; current users may upgrade to version 1.7 at a cost of $200.

Visionics Corp, 343 Gibraltar Dr, Sunnyvale, CA 94089. Phone (408) 745-1551.

Circle No 403



ANALOG SIMULATOR

PSpice, a program that lets you simulate and analyze analog electrical circuits, is now available on Sun workstations that run the Unix operating system with Sun Windows. The latest additions to the Sun family of options for PSpice are the Probe graphics postprocessor, the Parts parameter estimator, and the Digital Files option.

The Probe option lets you check the progress of a simulation and uses Sun Windows so that you can reposition or resize the Probe window at any time. Using the Parts option, you can construct a parts list and a cost estimate from the PSpice database.

The Digital Files option lets you convert the output of a digital simulator to a format that PSpice can use for a simulation run; alternatively, you can convert the output of PSpice to a format that a digital simulator can use. The option currently provides conversions to and from three formats: ViewLogic's ViewSim format; HHB Softron's Cadat format; and a generic format if you have some other digital simulator and can convert the generic format to your simulator's format. These options are also available for IBM PC and VAX/VMS machines. Prices depend on the host machine and range from $350 to $3800.

MicroSim Corp, 23175 La Cadena Dr, Laguna Hills, CA 92653. Phone (800) 826-8603; in CA, (714) 770-3022. TLX 265154.

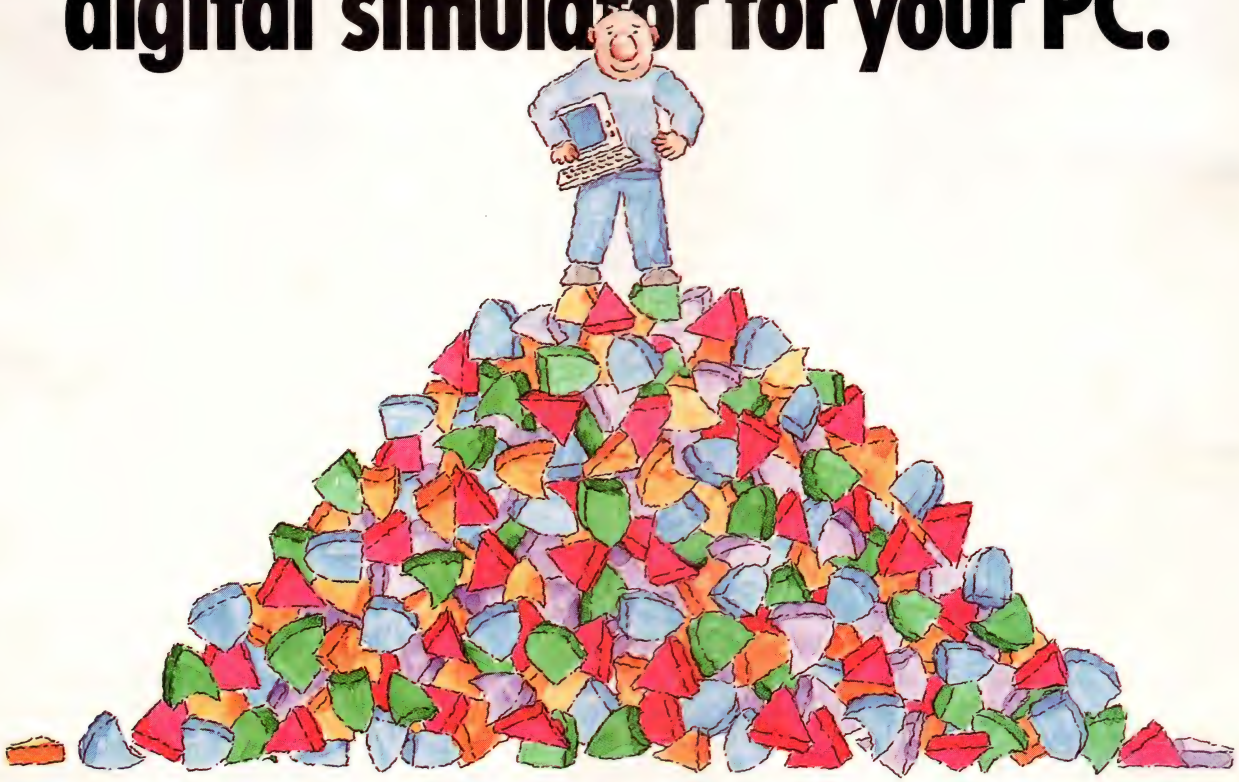
Circle No 404

DUAL-MODE SIMULATOR

Viewsim/AD is a mixed-mode analog and digital simulator system that runs on VAX computers under the VMS operating system. You can perform a single simulation run on a design that employs both analog and digital components. MicroSim's (Laguna Hills, CA) PSpice analog simulator processes the analog components; the vendor's Viewsim digital simulator processes the digital components.

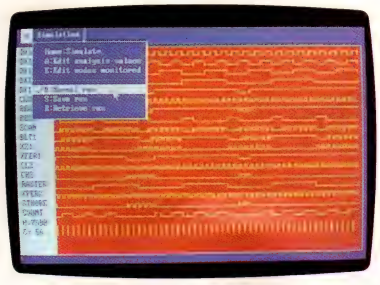
Both simulators run concurrently as separate tasks under VMS; a special interface, developed by MicroSim, synchronizes the two simulators and permits the transfer of information between them; extensions to Viewsim and the associated schematic editor, developed by the vendor, let you use your existing digital and analog device libraries to build

MICRO-LOGIC II.™
The CAE tool with a 10,000-gate digital simulator for your PC.



Spectrum Software's MICRO-LOGIC II® puts you on top of the most complex logic design problems. With a powerful total capacity of 10,000 gates, MICRO-LOGIC II helps engineers tackle tough design and simulation problems right at their PCs.

MICRO-LOGIC II, which is based on our original MICRO-LOGIC software, is a field-proven, second-generation program. It has a high-speed event-driven simulator which is significantly faster than the earlier version.



Timing Simulator

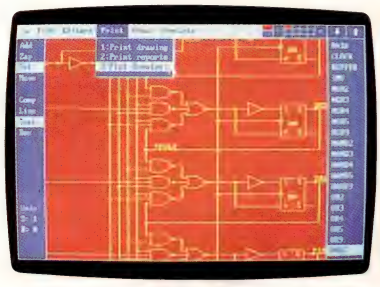
The program provides you with a top-notch interactive drawing and analysis environment. You can create logic diagrams of up to 64 pages with ease. The software features a sophisticated schematic editor with pan and zoom capabilities.

Shape Editor

A 200-type library of standard parts is at your fingertips. And for a new high in flexibility, a built-in shape editor lets you create unique or custom shapes.

MICRO-LOGIC II is available for the IBM® PC. It is CGA, EGA, and Hercules® compatible and costs only $895 complete. An evaluation version is available for $100. Call or write today for our free brochure and demo disk. We'd like to put you in touch with a top digital solution.

- Total capacity of 10,000 gates
- Integrated schematic editor
- Fast assembly language routines
- Standard parts library of 200 types
- Event-driven timing simulator
- Built-in shape editor
- Multiple delay models
- Printer and plotter hard copy



Schematic Editor

spectrum

1021 S. Wolfe Road, Dept. E
Sunnyvale, CA 94087
(408) 738-4387

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Hercules is a registered trademark of Hercules Computer Technology
IBM is a registered trademark of International Business Machines, Inc.

CIRCLE NO 113

mixed-mode designs that you can later simulate with Viewsim/AD. When you've completed the simulation, you can use the Viewwave waveform processor to display both analog and digital results interactively. The Viewsim/AD package includes Viewsim, PSpice, the special interface between them, and Viewwave. $25,000.

Viewlogic Systems Inc, 275 Boston Post Rd W, Marlboro, MA 01752. Phone (617) 480-0881. TLX 174242.

Circle No 406

LOGIC VALIDATOR

The Ikos 1900 is a modular logic-validation system that can simulate gate arrays and ASICs with as many as 245,000 gates. You pass schematic-capture data to the validator from the workstation on which you designed the circuit; the validator is compatible with most currently available ASIC-design workstations. You also pass test data to the validator from an IBM PC/AT or compatible machine, which provides the user interface for the validator; you can link multiple PC/ATs to the validator via an Ethernet LAN. The validator accelerates the entire sequence of logic-validation events; it processes input test cases (input pattern generation) and presents output results (logic analysis) while you're running a simulation. The user interface provides immediate feedback of detected errors so you can correct the errors at an early stage—you don't have to wait for information until the end of a batch run.

The validator's features include tools that create test data, fault-simulation tools to help design diagnostic procedures, multichip simulation, and a software logic analyzer. The basic validator system, consisting of user-interface software and hardware that can simulate as many as 16,000 gates, costs $54,950. Additional 16,000-gate evaluator boards cost $10,500 each.

Ikos Systems Inc, 145 N Wolfe Rd, Sunnyvale, CA 94086. Phone (408) 245-1900.

Circle No 408

ASIC EVALUATOR

Topaz II is a design-verification system that lets you test high-speed, high-gate-count ASIC prototypes. You can generate clock pulses at speeds as high as 100 MHz, and you can increase the test speed, in increments of 100 kHz, to a maximum of 50 MHz in order to characterize the maximum operating speed of the device under test. A shmoo-plot program lets you plot voltage and timing parameters over a wide range of other operating conditions; you can measure timing parameters with a resolution of 100 psec.

The basic system includes an integrated test fixture, programmable power supplies, an IBM PC/AT-compatible workstation that provides the user interface, and all software utilities. You can increase the number of device pins by 18-pin increments (16 I/O pins and two strobe pins) to a maximum of 288 pins. From $35,000.

HiLevel Technology Inc, 18902 Bardeen, Irvine, CA 92715. Phone (714) 752-5215. TLX 655316.

Circle No 409

FAULT EVALUATOR

The Fault Inferencer is a workstation-based fault evaluator that uses a critical-path-tracing algorithm. It first creates a fault list from the schematic-capture data on the design to be simulated and then collapses this list into different classes of indistinguishable faults. This collapsing process not only takes into account simple node equivalences, but also performs single-fanout and functional-fault collapsing. A preprocessor then removes all indistinguishable faults caused by inputs that are tied high or low, thereby further reducing the number of fault classes that must be considered.

The evaluator uses one fault from each class for simulation and runs a good-machine simulation to determine the state of all nodes for each vector; it determines fault coverage by back-tracing all critical paths. You can use either the vendor's pattern-generation language or an external file of test vectors as input to the evaluator. The reports it generates show the expected outputs from a faultless machine, as well as the fault classes detected for each vector. $45,000.

Aida Corp, 5155 Old Ironsides Dr, Santa Clara, CA 95054. Phone (408) 980-5200.

Circle No 410

INTERFACE

Using this graphics-software enhancement, you can upgrade Silvar-Lisco schematic capture, simulation, and pc-board layout software, running on the company's 6000 Series graphics workstations to provide additional display capabilities. The software allows any 6000 Series workstation to drive two monitors independently, allowing you to display two separate graphics images

simultaneously. For example, you can hold an image on one monitor while you zoom in on an area of particular interest with the other monitor. The display resolution for each display head is 1448×1024 pixels with 256 displayable colors. The software runs with the Silvar-Lisco Coregraph graphics driver. £250.

Sigmex Ltd, Sigma House, N Heath Lane, Horsham, W Sussex RH12 4UZ, UK. Phone (0403) 50445. TLX 877937.

Circle No 419

PC-BOARD CAD

In addition to providing you with the company's Solution-4000 pc-board layout software, the Kit-Solution-4000 includes the graphics board necessary to convert a DEC Micro-PDP computer into a suitable workstation for the software. You can use the kit on any Micro-PDP computer that uses the 11/23, 11/73, or 11/53 CPU with 256k bytes of RAM. The resultant workstation allows you to perform schematic capture, to design multilayer pc boards using interactive or fully automatic placement and routing, and to produce pc-board manufacturing documentation. SFr 40,600.

Academi Systems SA, 50 Avenue de la Praille, 1227 Geneva, Switzerland. Phone 022-432760. TLX 422842.

Circle No 417

Academi Systems Inc, 2418 Armstrong St, Livermore, CA 94550. Phone (415) 449-3294. TWX 910-240-7812.

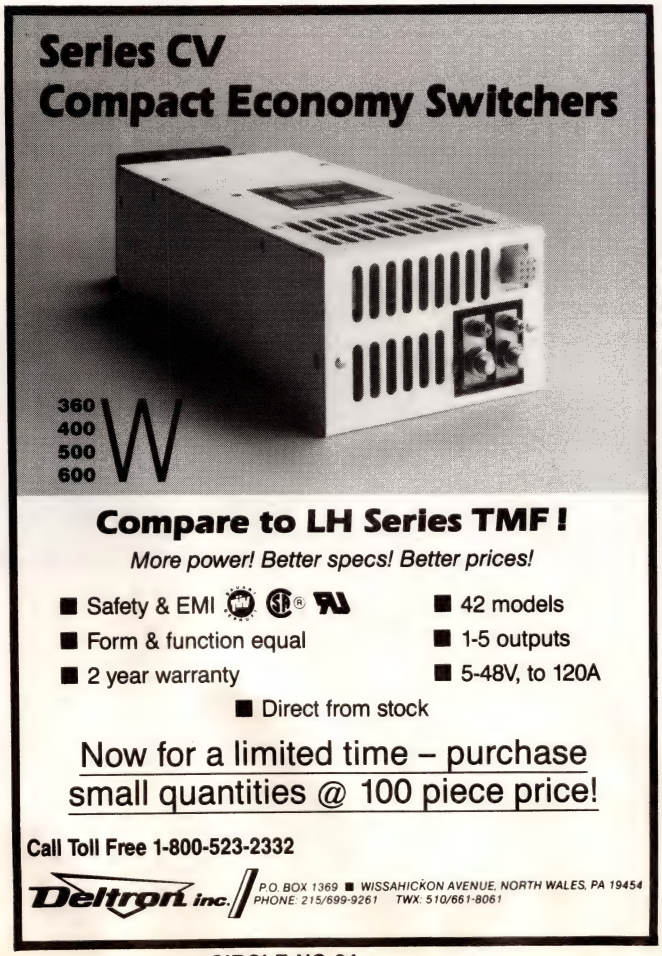
Circle No 418

LOGIC SIMULATOR

OrCAD/VST (verification and simulation tools) is an event-driven digital-logic simulator that runs on the IBM PC and compatibles. You start a simulation by calling up a net list that's generated by the vendor's OrCAD/SDT (schematic design tools) package. OrCAD/VST then links the design and builds the simulation model. Next, you use the menus to specify as many as 200 input stimuli and to define the signals the program is to trace. Because the program uses a virtual screen, you can display as many as 50 signals or buses and place as many as three markers on the screen. When running on an 8-MHz PC/AT, the program can handle as many as 10,000 events/sec. The program comes with a library that includes models of all popular TTL, ECL, CMOS, and memory devices. You can add new models to the library with the aid of the component-modeling program supplied with OrCAD/VST. $995.

OrCAD Systems Corp, 1049 SW Baseline St, Suite 500, Hillsboro, OR 97123. Phone (503) 640-5007.

Circle No 412



CIRCLE NO 34

CIRCLE NO 28

MIL-spec DEC systems and MIL-spec single-board computer *(Raytheon)*

MIL-spec (left) and ruggedized (above) versions of the Data General MV 8000 Series computer *(Rolm Mil-Spec Computers)*

Low-cost, rugged commercial computers fit military needs

To let your military application take advantage of the wealth of software and support—such as field service and peripherals—that exists for commercial computers, you can use either a MIL-spec or a ruggedized version of a commercial computer system. Which type you choose will depend on a number of cost/performance tradeoffs.

Margery S Conner, *Regional Editor*

A number of commercial minicomputers and microcomputers are available in MIL-spec and ruggedized versions that you can use in certain military applications. Most of these computers are available as complete systems, but some come as boards. MIL-spec and ruggedized computers have three main advantages over systems based on specialized military architectures. First, the MIL-spec or ruggedized boards are built from more current technology. Second, many hardware and software engineers are familiar with the architectures of these commercial boards, and finally, field service for them is easier to arrange.

When you choose between a MIL-spec version and a ruggedized model, you'll face certain tradeoffs. MIL-spec versions have the advantage of meeting the environmental and manufacturing requirements of all the branches of the US military. However, they cost more and are based on less-current technology than versions that are merely ruggedized. A ruggedized version lets you take advantage of the most current technology at a considerable cost savings. However, these products are limited to non-mission-critical applications. You can use **Tables 1** and **2** to compare the specifications and prices for a representative sample of MIL-spec and ruggedized commercial computer systems.

The cost and lead-time premium you'll incur when you buy a MIL-spec computer board results from the design, manufacturing, and test requirements inherent in military-qualified systems. A MIL-spec version must meet the performance specifications of its commercial counterpart, while being built entirely from scratch with all-MIL-spec components. The assembly and test processes are also controlled by military specifications. Because most of the commercial computers employ proprietary ICs, the manufacturer of the MIL-spec version not only incurs the time delay associated with developing a complicated MIL-spec IC, but also must foot licensing and developmental costs for the proprietary parts.

You have good reason to question quality

Historically, the military hasn't used commercially available components and equipment; the parts were often unreliable because of manufacturing problems in the semiconductor industry. Military-qualified electronics equipment couldn't be unreliable; it had to meet design and manufacturing requirements that ensure that the equipment would not fail because of a harsh environment. Commercial systems were also not suitable for military use. The commercial sector did not design systems to maintain their performance specs under worst-case conditions, a practice the military

Ruggedized computers cost about half what a MIL-spec version costs and yet use more-current technology.

normally follows. These factors combined to produce systems that were too unreliable for use in harsh environments.

MIL-spec procedures evolved to enforce worst-case analysis, manufacturing control, and documentation of all the associated steps of producing products to be sold to the military. This regimen forces a manufacturer who sells systems to the military to follow good design and manufacturing practices and prove that it's following them.

Both design and manufacturing procedures are changing in the commercial electronics industry, however. As the gate capacity of off-the-shelf, custom, and semicustom ICs increases, the number of pc-board interconnects decreases and the reliability over the life of the product increases. In addition, CAD tools at both the IC and the board level enforce good, consistent design practices. And the need to remain competitive is now forcing commercial manufacturers to produce high-quality, reliable products, which in turn requires good manufacturing practices. In sum, the pressures of the market are prompting manufacturers of commercial products to use military design and documentation standards.

Analog Devices (Norwood, MA), for example, a major manufacturer of linear devices for military as well as commercial applications, makes both the commercial and the MIL-spec versions of its parts on the same production line. Yet the military parts cost more, the company admits frankly, because of the additional cost of military documentation and testing. Indeed, you might surmise that the single largest item produced by the defense industry is paper.

In an attempt to combine higher-quality commercial parts with MIL-spec manufacturing techniques, Raytheon is preparing to offer DEC VAX-compatible computers in three versions: standard, extreme, and hardened. The standard version will use screened and burned-in commercial-grade components; it will also meet or exceed the requirements of MIL-E-16400 class 4 (shipboard sheltered). The extreme system will be a high-reliability implementation that uses MIL-STD-883B or higher-grade components and meets or exceeds the requirements of MIL-E-16400, MIL-E-4168, and

TABLE 1—REPRESENTATIVE MIL-SPEC COMMERCIAL COMPUTERS

MANUFACTURER	MODEL	COMMERCIAL VERSION	TEMPERATURE (°C)	HUMIDITY	ALTITUDE (FT)	VIBRATION	OUTSIDE DIMENSIONS (IN.)	WEIGHT (LBS)
AEROFLEX LABORATORIES	ARX 3/50	SUN 3/50	−55 TO +85°C	100%[3]	70,000	10G, 5 TO 2000 Hz	7.56×10.12×10.44	20
MILTOPE CORP	TAC-PC	IBM PC/AT	−20 TO +60°C[1], −40 TO +71°C[2]	95%[4]	16,000[1] 50,000[2]	5G, 50 TO 2000 Hz	12.25×15.0×19.65	65
NORDEN SYSTEMS	MIL VAX II	DEC MICROVAX II	−54 TO +55°C[1], −62 TO +85°C[2]	100%[3]	35,000	5G, 5 TO 2000 Hz	7.62×10.12×19.62	50 TO 90
ROLM MIL-SPEC COMPUTERS	1900 HAWK/32 SERIES	DATA GENERAL MV 8000	−55 TO +71°C	95%[4]	70,000	5 TO 2000 Hz	7.68×12.62×22.97	90 (MAX)
TITAN/SESCO	SECS-80 500 MCS SERIES	INTEL iSBC	−55 TO +71°C	100%[3]	70,000	10G, 5 TO 2000 Hz	9.44×14.95×13.38	36
	SECS 286[5]	INTEL iSBC 80286-BASED	−55 TO +71°C	—	—	—	—	—
	SECS 186[5]	INTEL iSBC 80186-BASED	−55 TO +71°C	—	—	—	—	—

NOTES:
1. OPERATING
2. NONOPERATING
3. CONDENSING
4. NONCONDENSING
5. SINGLE-BOARD COMPUTER

MIL-spec version of Sun system
(Aeroflex Laboratories)

MIL-E-5400T class 2. The hardened computers will be able to survive tactical levels of nuclear weapons effects (NWE). The three versions will be available in 1988.

If a MIL-spec computer is too expensive for your application, consider a ruggedized computer. Unlike products that meet military specifications, ruggedized equipment is commercial equipment that's purchased from a commercial vendor and repackaged to be able to operate in harsh environments.

As an analogy for the difference between a ruggedized version of a computer and a MIL-spec version, consider a raw egg. Engineering students demonstrate the ruggedized-packaging approach each year during Engineering Week when they design a package that enables a fresh egg to withstand a drop of about 100 feet. The egg has been ruggedized. A MIL-spec version of the egg would require the chicken (the original manufacturer) to license the engineering students to design and manufacture a substance that would perform the function of a raw egg, yet meet the environmental condition of surviving a 100-ft drop.

Keep in mind, however, that there's no set definition of ruggedization. In general, the systems covered in **Tables 1** and **2** contain commercial pc boards and have ruggedized chassis, board mounts, power supplies, and peripheral equipment. The ruggedized parts **(Table 2)** meet some version of various environmental MIL specs. For example, all the systems meet MIL-STD-810D requirements for shock resistance of as much as 15g while operating and 20g while not operating, and resistance to vibration inputs of 2g applied in a sinusoidal manner. And in every system listed, all internal cabling is coated with Teflon rather than with PVC. You'll need to check the specification sheets of the particular ruggedized system you're considering to make sure it will meet your application's requirements.

As mentioned, a ruggedized computer is less expensive and can incorporate more current technology than a MIL-spec version. Joel Avery, product manager for Rolm Mil-Spec Computers, estimates that a manufac-

MAX MEMORY (BYTES)	OPERATING SYSTEM	PRICE	COMMENTS
16M	UNIX	$25,000 TO $35,000	
640k	MS-DOS	$25,500	ELECTROLUMINESCENT DISPLAY
16M	VMS, VAXELN, ULTRIX-32	$175,000 TO $250,000	RUGGEDIZED VERSION AVAILABLE
32M	AOS/VS, ARTS/32	$175,000 (MODEL 2900)	RUGGEDIZED VERSION AVAILABLE
256k (EPROM), 768k (RAM)	iRMX, VRTX-86	$64,000 TO $72,000	INCLUDES KEYBOARD AND ELECTROLUMINESCENT DISPLAY
MEMORY MODULE OPTIONAL	iRMS, VRTX, MTOS-UX	$11,775	HAS RS-232C/RS-422 AND RS-232C PORTS; LOCAL BUS I/O. ADD $1450 FOR 80287 COPROCESSOR
12k (EPROM), 64k (RAM)	iRMS, VRTX, MTOS-UX	$13,550	HAS RS-232C/RS-422 AND RS-232C PORTS; LOCAL BUS I/O. ADD $1275 FOR 8087 COPROCESSOR

Market demand for higher quality has increased the quality of commercial electronics equipment.

turer can bring a ruggedized version of a commercially available computer to market in three to nine months, while a full-MIL-spec version requires 18 months to three years. The cost of the ruggedized version will be about 50% of the cost of the MIL version. Under license from Data General, Rolm makes both a MIL-spec and a ruggedized version of its Hawk/32 series of Data General MV 8000 Series computers. The MIL-spec Model 1900 measures 7.68×12.62.×22.97 in. and costs $175,000. The ruggedized Model 2900 measures 8.75×19×24 in. and costs $88,000.

Remember the commercial market's volatility

As you consider MIL-spec and ruggedized computers, be aware that some drawbacks accompany the advantages of buying on the commercial market. That market is volatile, after all, so commercial products, likewise, are subject to rapid change. This idea runs counter to the military philosophy of retaining control over equipment changes. For example, suppose that you're designing a system that will incorporate a ruggedized version of an IBM PC-compatible chip set. If your product will have a manufacturing lifetime of, say, 10 years, you'll need to be sure that the chip set will still be available in 10 years. In the fast-changing personal-computer market, however, it's quite possible that the chip set won't last that long. The military market has not tolerated such fast-paced change.

One solution to this problem would be for the ruggedizing company (the OEM) to retain a manufacturing license from the original manufacturer of the commercial product. If the commercial company ceases to manufacture the product, the ruggedizing company would then have the right to do so. However, this event could cause sharp increases in the OEM's equipment-production costs.

CAD/CAE tools promote quality

Because commercial IC and component manufacturers are increasingly using CAD/CAE tools, however, the problems of discontinued parts and of less-than-rigorous design practices are diminishing. Not only do these tools make it feasible for the manufacturers to design and make semicustom chips, but they also prom-

TABLE 2—REPRESENTATIVE RUGGEDIZED COMMERCIAL COMPUTER SYSTEMS

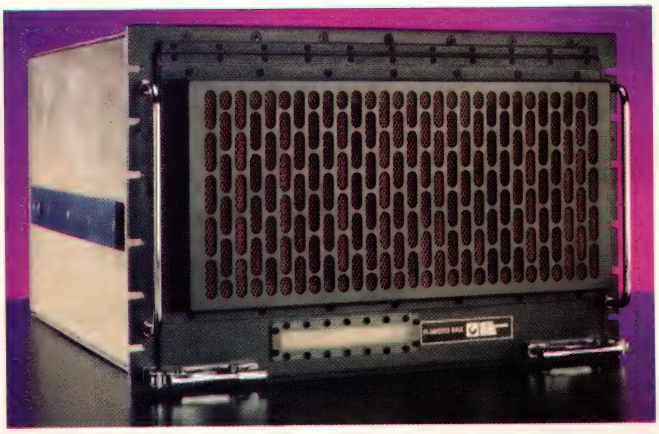
MANUFACTURER	MODEL	CPUs SUPPORTED	TEMPERATURE (°C)	HUMIDITY	ALTITUDE (FT)	VIBRATION	OUTSIDE DIMENSIONS (IN.)
MDB SYSTEMS	RCS MODEL 21P	DEC LSI 11/73 PDP 11/83 MICROVAX II	0 TO 50°C[1] −30 TO +70°C[2]	90%[4]	10,000	2G, 50 TO 2000 Hz	17×17×23.5
MILTOPE CORP	TIGER	IBM PC/AT	−10 TO +55°C[1] −55 TO +71°C[2]	95%[4]	15,000[1] 40,000[2]	2G, 50 TO 2000 Hz	7.0×17.62×24.5
NORDEN SYSTEMS	RUGGED PDP-11	DEC PDP-11	0 TO 50°C[1] −40 TO +70°C[2]	90%[4]	10,000[1] 40,000[2]	1.4G, 10 TO 2000 Hz	12.25×16.87×23.00
ROLM MIL-SPEC COMPUTERS	2900 HAWK/32 SERIES	DATA GENERAL MV 8000	0 TO 55°C[1] −40 TO +85°C[2]	95%[4]	10,000	2G, 20 TO 2000 Hz	8.75×19.0×24.0
RUGGED DIGITAL SYSTEMS	R/630	DEC MICROVAX II	0 TO 50°C[1] −40 TO +70°C[2]	10 TO 90%	10,000[1] 40,000[2]	2G, 50 TO 2000 Hz	12.25×19.0×22.5
	R/8250	DEC VAX 8250	0 TO 50°C[1] −40 TO +70°C[2]	10 TO 90%	15,000[1] 40,000[2]	2G, 50 TO 2000 Hz	12.25×19.0×21
	R/1184	DEC PDP 11/84	0 TO 50°C[1] −40 TO +70°C[2]	10 TO 90%	15,000[1] 40,000[2]	2G, 50 TO 2000 Hz	12.25×19.0×21.5
TRILOBYTE COMPUTER CORP	TRILOBYTE V	IBM PC/AT	0 TO 55°C[1] −45 TO +65°C[2]	100%[3]	10,000[1]	4.5G, 5 TO 2000 Hz	15.75×16.87×25.0
	TRILOBYTE IV	DEC VAX 11/780	0 TO 50°C[1] −33 TO +71°C[2]	90%[4]	10,000	4.5G, 5 to 2000 Hz	12.25×19.0×22.5

NOTES:
1. OPERATING
2. NONOPERATING
3. CONDENSING
4. NONCONDENSING

ulgate tighter design rules than you could previously count on from the commercial sector.

Further, the government actually favors the use of nondevelopmental items (commercial equipment) for certain applications as long as the equipment meets performance requirements. This endorsement has coincided with the military's emphasis on C^3 (communication, control, and command) equipment. Because it's typically deployed in noncombat stations, C^3 equipment can often take advantage of the cost savings afforded by ruggedized equipment. Because C^3 equipment is deployed in noncombat stations, it doesn't always have to meet strict MIL specs; instead, it can be ruggedized. These two factors have prompted several companies to introduce new ruggedized products.

Don't assume that ruggedization will become the predominant trend in military electronics, however. Equipment intended for mission-critical applications—which usually means combat situations—must be able to tolerate environmental extremes. For example, you can't rely on outside air for cooling pc boards inside a system intended for a combat environment. The air in a combat environment might contain compounds that corrode metal.



Rugged chassis for either a DEC Micro-PDP-11 or MicroVAX II *(Norden Systems)*

Whether an application requires MIL-spec products depends on other factors as well. On a naval vessel, for instance, the shipboard computer that handles mundane accounting tasks might well be ruggedized. But the ship's fire-control system will most likely be a MIL-spec version. Then again, even some noncombat applications require nothing less than full MIL-spec equipment. Two examples would be equipment used in space, and equipment specified to survive a nuclear blast. (Of course, humans can only be ruggedized—we have no MIL-spec humans to run the surviving equipment.)

Whether you decide on a MIL-spec or a ruggedized computer for your application, you'll find a wide assortment of equipment from a number of manufacturers to choose from, including microcomputers, single-board computers, and minicomputers.

Because of the popularity of the personal computer, the microcomputer is finding favor in military markets. Echoing its success in industrial applications, the IBM PC and its derivatives, the PC/XT and PC/AT, are the most popular. As in the commercial sector, its popularity results from the fact that it's inexpensive and readily available, that it has abundant software support, and that a multitude of engineers are already familiar with it.

Miltope Corp has both a MIL-spec and a ruggedized version of a portable PC/AT. The MIL-spec TAC-PC includes an 80-column, 25-line ac plasma display and cost $25,500. The ruggedized Tiger is based on Hewlett-Packard's Vectra PC/AT compatible and has an upgraded electroluminescent display that's compatible

	WEIGHT (LBS)	PRICE	COMMENTS
	80 TO 100	$55,000 TO $61,000	INCLUDES RX50 FLOPPY-DISK DRIVE AND REMOVABLE RD53 HARD-DISK DRIVE
	35	$14,000	RUGGEDIZED HEWLETT-PACKARD VECTRA
	<100	$50,000 TO $125,000	
	72 TO 80	$88,000	RUGGEDIZED VERSION OF MODEL 1900
	65 TO 100	$75,000 (TYPICAL SYSTEM)	
	90 TO 105	$150,000 TO $300,000	R/8350 VERSION AVAILABLE WITH TWO R/8250 CPU BOARDS
	90 TO 105	$100,000 TO $125,000	
	80	$5950	INCLUDES ZENITH PASSIVE BACK-PLANE AND PROCESSOR, MEMORY, AND MULTIFUNCTION BOARDS
	70	$30,320	INCLUDES RD53 HARD-DISK DRIVE, TK50 TAPE DRIVE, AND 1M BYTE OF RAM

Because no formal definitions exist for ruggedization, you must check each ruggedized product's specs to make sure it will meet your application's requirements.

with IBM's Color Graphics Adapter (CGA). It has space for three half-height floppy- or hard-disk drives.

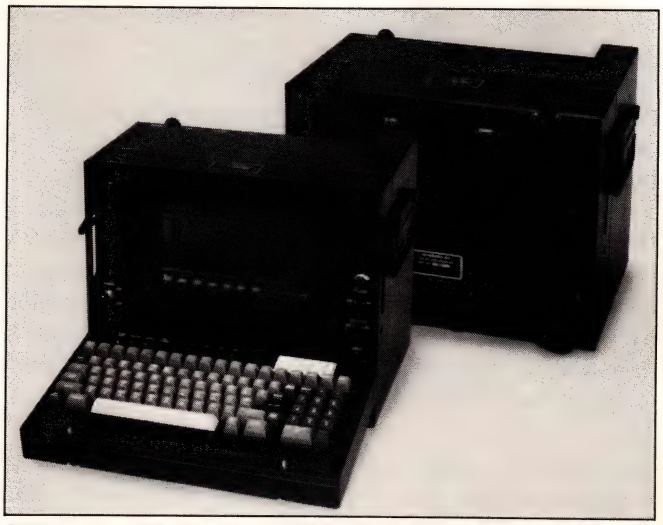
Trilobyte Computer offers the Trilobyte V ruggedized IBM PC/AT-compatible system without boards, which you can configure with any hardware you choose. Alternatively, they sell the system fully configured with a Zenith passive backplane (instead of the traditional mother board configuration) and processor, memory, and multifunction boards for $5950.

Apple's MacIntosh II may also become popular with the military. Keep in mind that Apple (Cupertino, CA), has pursued a different approach to providing alternate sources and ruggedized versions of its Macintosh II than IBM has with its PCs. Although IBM has allowed manufacturers to clone the PC with impunity in the past, Apple has kept much tighter control over its alternate sources. Apple has signed a licensing agreement with Magnavox to provide a ruggedized version of the Macintosh II.

These MIL-spec and ruggedized microcomputers are either portable or rack mountable. If you need to embed a single-board computer in your system, consider Titan/Sesco's line of Intel iSBC-compatible boards. The SECS 80 Series—available in versions with 80286, 80186, and 8086 μPs—offers a choice of operating systems: iRMX, MTOS-UX/86, and VRTX.

VRTX, a real-time operating system, is attractive because it can read and write MS-DOS files. Although MS-DOS is the most common operating system for personal computers, it does not perform well in a real-time environment. And little of the available MS-DOS software is useful in a battlefield environment—few soldiers have the urge to run a spreadsheet while under fire. Battlefield programs may need to access databases generated by an MS-DOS program, however. Similarly, the data gathered on the battlefield may subsequently need to be analyzed by an MS-DOS program. VRTX allows a real-time computer to read and write such MS-DOS files.

If your deeply embedded system requires the mini-



MIL-spec model of a portable PC/AT *(Miltope Corp)*

For more information . . .

For more information on the MIL-spec and ruggedized computers discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Aeroflex Laboratories Inc
35 S Service Rd
Plainview, NY 11803
(516) 694-6700
Circle No 701

MDB Systems Inc
Box 5508
Orange, CA 92613
(714) 998-6900
TWX 910-593-1339
Circle No 702

Miltope Corp
1770 Walt Whitman Rd
Melville, NY 11747
(516) 420-0200
TWX 510-221-1803
Circle No 703

Norden Systems
40 Continental Blvd
Merrimack, NH 03054
(603) 424-8200
Circle No 704

Raytheon Co
Equipment Div
528 Boston Post Rd
Sudbury, MA 01776
(617) 443-9521
Circle No 705

Rolm Mil-Spec Computers
One River Oaks Pl
San Jose, CA 95134
(408) 432-8000
TWX 310-372-5902
Circle No 706

Rugged Digital Systems Inc
328 Gibraltar Dr
Sunnyvale, CA 94089
(408) 747-1770
Circle No 707

Titan Corp
Sesco Div
20151 Nordhoff St
Chatsworth, CA 91313
(818) 709-7100
TLX 691404
Circle No 708

Trilobyte Computer Corp
1447 Catalina St
San Leandro, CA 94577
(415) 895-1100
TWX 910-350-0171
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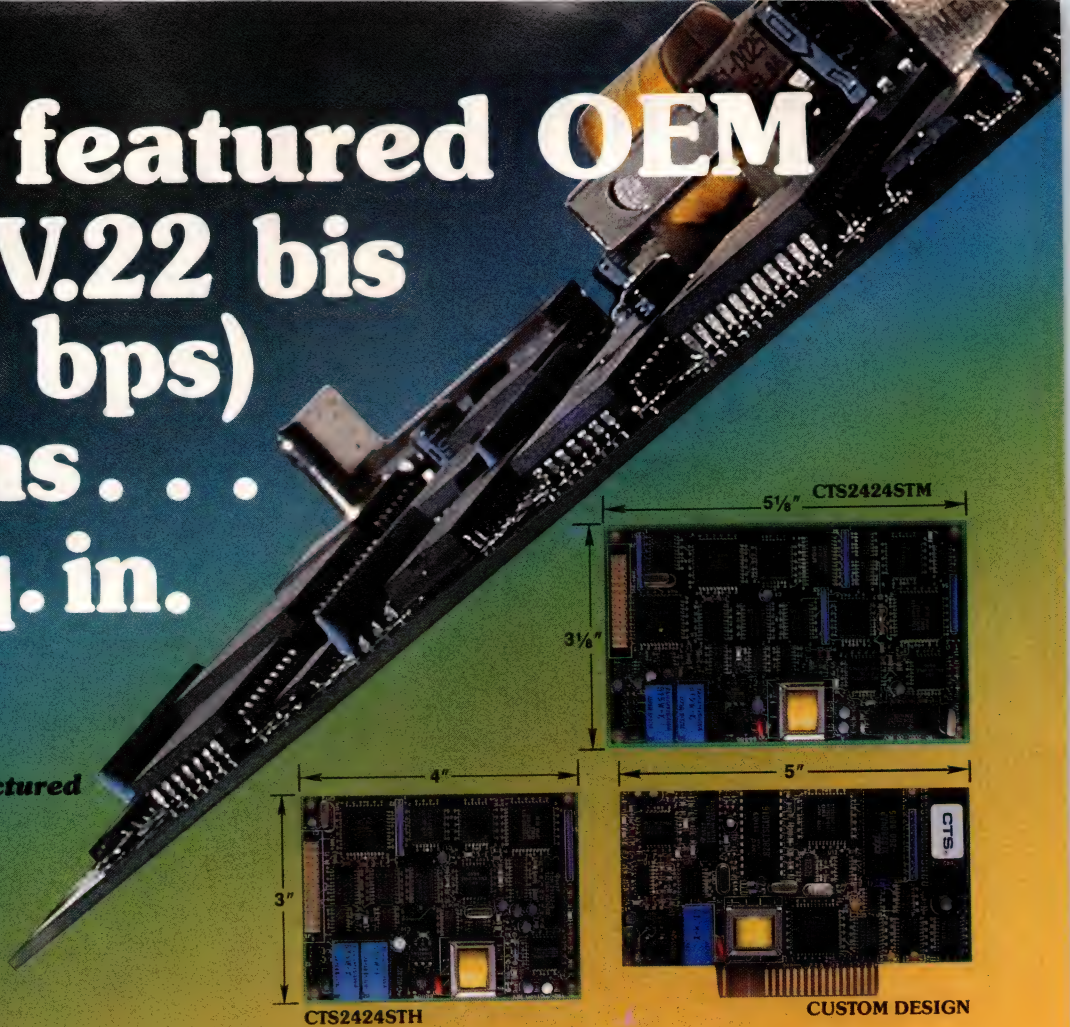

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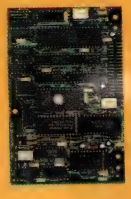
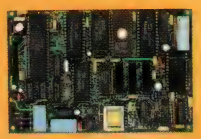
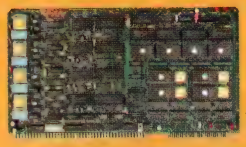


Data Pump Custom Designed 2400 Full Duplex Modem.
Circle No. 105



TTL Interfaced 2400 bps Full Duplex Modem for Small Quantity Users.
Circle No. 106



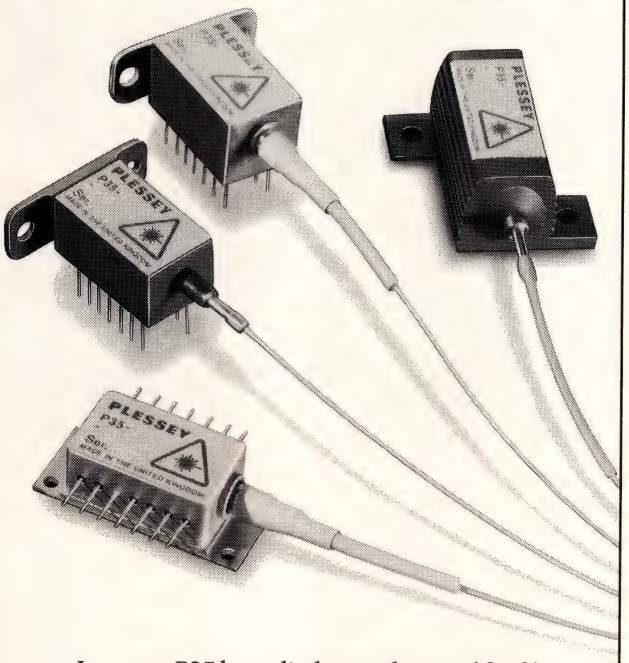
Quadmodem Four 2400 bps Full Duplex Modems on One Board
Circle No. 107

Half-Pak #24 IBM† PC Compatible Half Card 2400 bps Modem
Circle No. 108

New to the Industry Since 1896.

*Registered trademark of Microcom. ‡Registered trademark of Hayes Microcomputer Products, Inc. †Registered trademark of International Business Machines, Inc.

LASER DIODES TO ACCELERATE TRANSMISSION.



Low-cost P35 laser diodes are designed for fibre optic transmission systems operating up to 140 Mbit/s and for trunk systems up to 565 Mbit/s.

P35 9300 SERIES FEATURES

- Cooled and uncooled variants
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- Pigtailed or connectorised versions
- ECL coupled module
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Plessey Optoelectronics is committed to the practical needs of an international market. From a pioneering R&D base, and an impressive manufacturing facility, it produces both standard and customised fibre optic devices in volume, and provides problem-solving design engineering services for its customers.

Plessey Optoelectronics Limited, Product Marketing Division, Wood Burcote Way, Towcester, Northants. NN12 7JS. Tel: (+44) 0327 51871. Telex: 312428.

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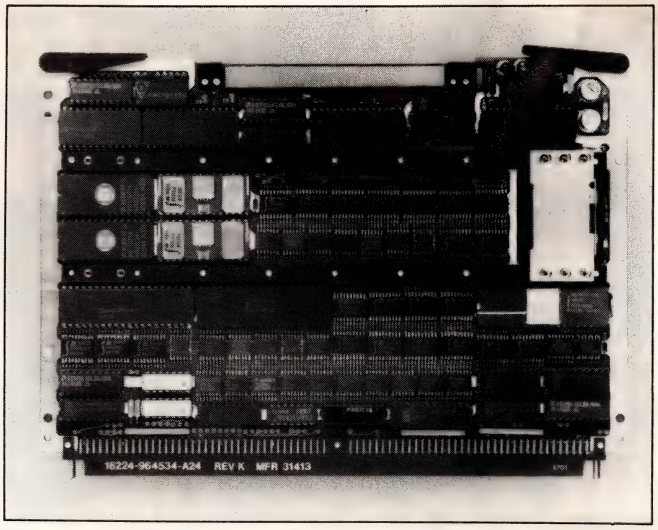
158 **CIRCLE NO 12**



MIL-spec 80186-based single-board computer with arithmetic co-processor *(Titan/Sesco)*

computing power of a VAX, note that Raytheon expects to offer the 810, a single-board computer featuring 32-bit-wide VAX architecture. The board also has a hardware floating-point accelerator, as well as 256k bytes of RAM and a 256k-byte PROM. Its input and output take place either through two RS-423 serial ports or through a 13.3M-byte/sec VAXBI I/O bus. The real-time VAXELN operating system is the only OS available for the board.

MIL-spec and ruggedized minicomputers available as systems consist of a processor board, mounting chassis, and power supply. You add memory and peripherals as needed. On the MIL-spec side, Raytheon and Norden are the DEC VAX licensees, while Rolm is the Data General MV 8000 Series licensee. Your choice of a ruggedized minicomputer includes Rugged Digital for DEC and Rolm for the Data General.

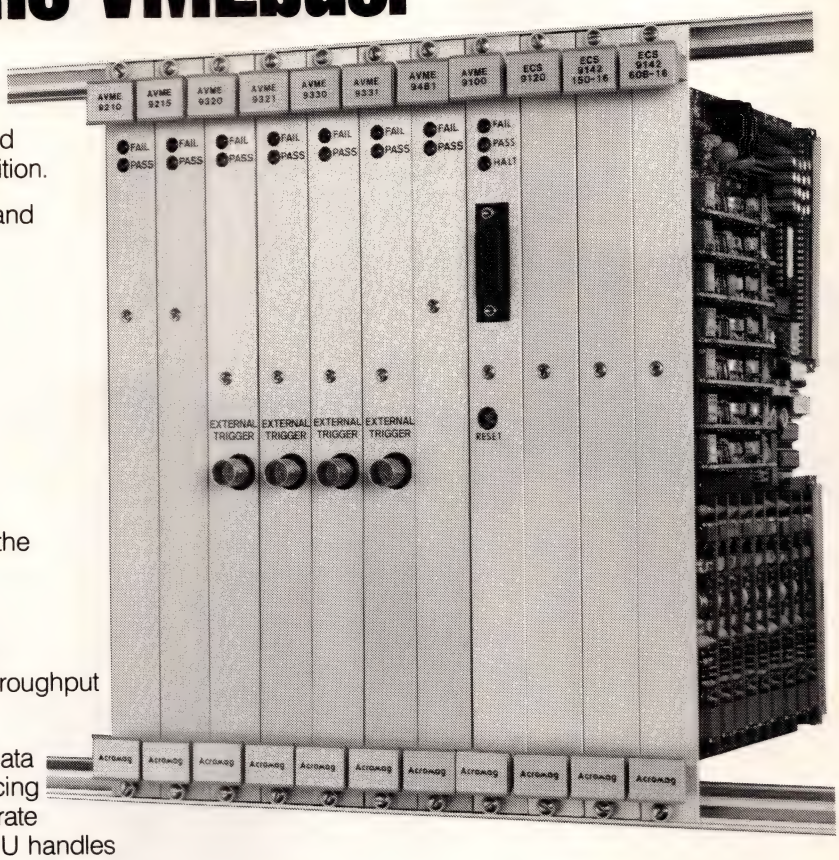
Because Rolm offers a MIL-spec and a ruggedized version of the same computer, you can change from MIL-spec to rugged or rugged to MIL-spec if your application's requirements should change. It's quite possible that after selecting one version and field-testing it in your application, you may decide that its environmental and reliability requirements are tighter or looser than you originally thought. The choice between a MIL-spec and a ruggedized system is a relatively new one. Until the military and its contractors gain more experience in judging the criteria used to select MIL-spec and ruggedized equipment, the ability to choose between a MIL-spec and ruggedized version of the same computer may be important. **EDN**

Reference

Schultz, James B, "Ruggedized computers offer low-cost readiness," *Defense Electronics*, January, 1987, pg 69.

Article Interest Quotient (Circle One)
High 482 Medium 483 Low 484

Acromag has solutions for interfacing A/D, D/A and Digital I/O signals to the VMEbus.



Our extensive line of VMEbus-based products handles your interfacing applications for test and measurement, industrial control, or data acquisition.

If you need to interface with industrial sensors and industry standard field signals:

DC VOLTS OR CURRENTS
MILLIVOLT
THERMOCOUPLE
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FREQUENCY

We have total solutions from the field wiring to the VMEbus.

PERFORMANCE

For basic A/D conversion, we've incorporated many operational features to improve overall throughput to your host processor.

For more advanced applications, Acromag's Data Acquisition Subsystem simplifies sensor interfacing and reduces host activity. So you can concentrate on processing the data while our on-board CPU handles routine tasks.

Function	In/Out	Max Signal Range**	Features	Product
High-Speed Analog I/O	16D/32SE*in 2 out, opt.	±10 in/out	12 Bit A/D, 67K chan/sec throughput 12 Bit D/A	AVME9320 AVME 9321
High-Res. Analog I/O	16D/32SE in 2 out, opt.	±10 V in/out	14 Bit A/D, 33K chan/sec throughput 12 Bit D/A	AVME 9330 AVME 9331
Analog Out	8 out	±10V, Vout 4-20mA, Iout	12 Bit D/A, 6 μ sec Vout, 25 μ sec Iout, throughput	AVME9210 AVME 9215
Data Acq. Controller	16D/32SE in, opt.	±10V	14 Bit A/D, 256 in, scans, linearizes, limit checks	AVME9100 AVME9110
Subsystem Expanders	16D/32SE in	±10V	High level expander	ECS9120
	16D in	±10V	Filtered inputs	ECS9121
	8D/16D in	−6 to +60mV −15 to +150mV Thermocouple	250V isolation, interface for TC, RTD, and Pressure with termination panels	ECS9142-60 ECS9142-150 ECS9142-60B
Digital I/O	64 in/out	0-30V in/out	8 in with latch and interrupt	AVME9480 AVME9481

*SE - Single ended D - Differential
**Most inputs and outputs have programmable ranges.

SUPPORT PRODUCTS

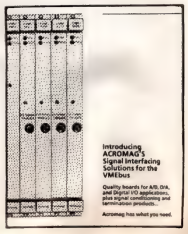
Acromag's termination products interface to your field wiring using screw terminals and to the VME backplane using ribbon cable. I/O connections are at the rear of the boards.

The modular, high-accuracy analog signal conditioning system connects to any of our VME high-level analog boards—like a termination panel. Available modules cover virtually all signal types and provide electrical isolation.

And we provide a comprehensive software support package for VERSAdos—with drivers, diagnostics, and a subroutine library in 'C'.

QUALIFICATIONS

Let Acromag's 30 years of experience in signal interfacing benefit you. When you need to interface analog or digital signals to the VMEbus, call or write today. For more information request "Acromag's Signal Interfacing Solutions for the VMEbus" bulletin.



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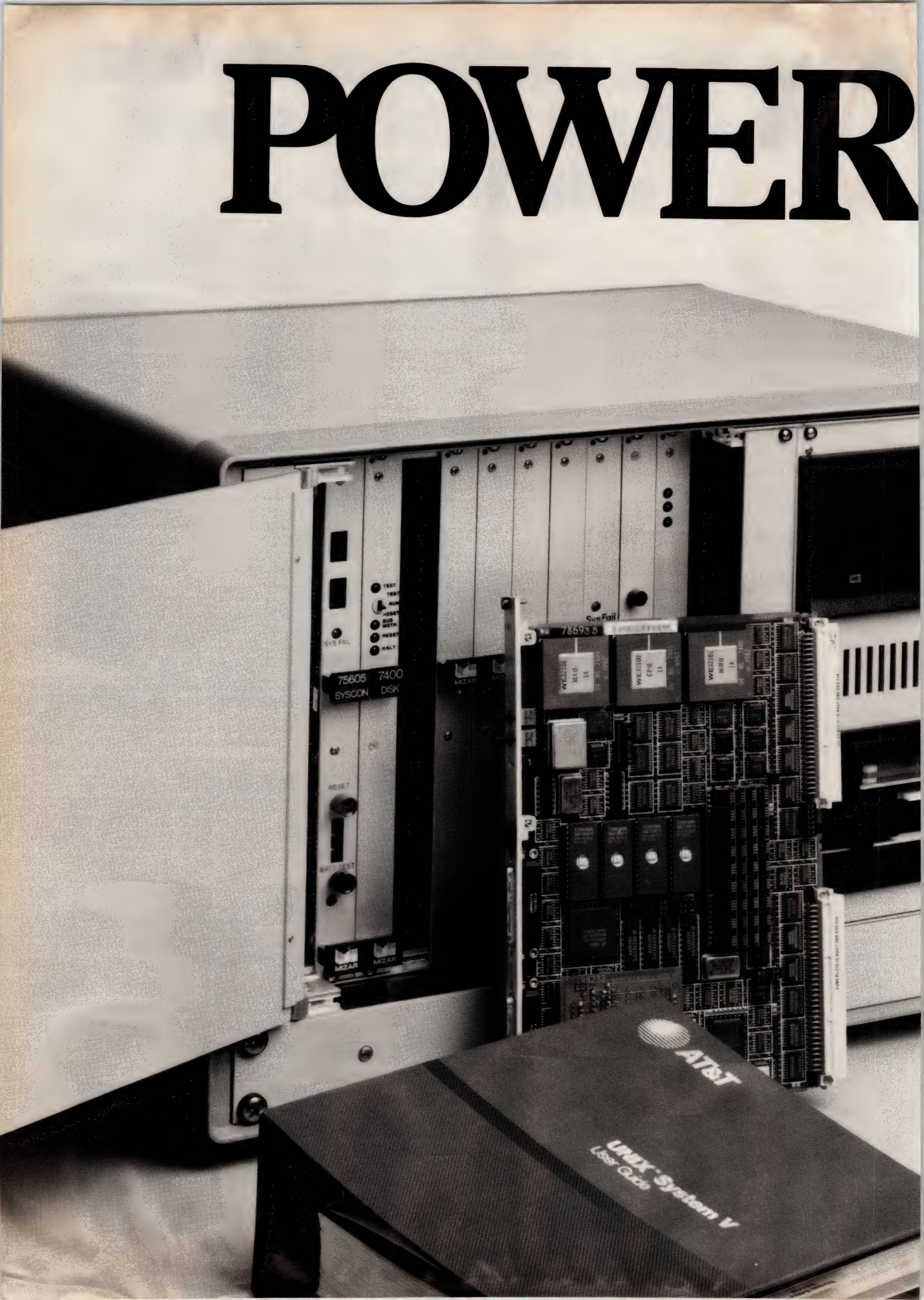
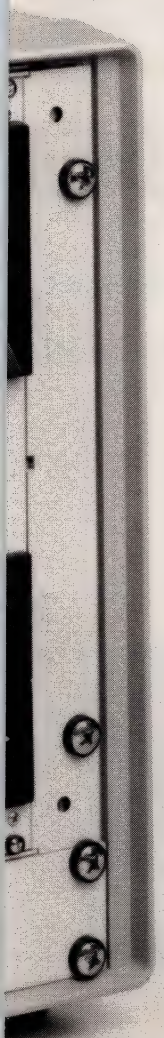
CIRCLE NO 114

POWER


SYS FAIL
75605 7400
SYSCON DISK
RESET
MIZAR
AT&T
UNIX System V
User Guide

TOOLS.



MIZAR INTRODUCES UNISTAR-32™...THE FIRST AT&T 32100®-DRIVEN VME DEVELOPMENT SYSTEM TO UNLEASH THE FULL POTENTIAL OF UNIX™.

Mizar's new Unistar-32 VME/UNIX gives a whole new meaning to power with the most sophisticated development system available for UNIX-based software applications. It's the first super microcomputer to provide system designers with powerful mainframe performance in a multi-user, multi-tasking software development system.

A new, multi-lingual microprocessor family
AT&T's full 32-bit set of matched WE® 32100 VLSI chips form the nucleus of the Unistar-32 central processing VME module. Designed to optimize the operation of both C high level language and UNIX System V/VME, this unique CPU module also offers you a general purpose, coprocessor interface which facilitates CPU interaction with the memory management unit and the math accelerator unit.

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UNIX System V/VME was written specifically for the WE 32100 microprocessor and its family of peripherals. It has been tuned for the VME environment, undergone extensive field testing and supports more than 1500 commercially available application programs. By porting the latest UNIX system to VMEbus, the optimized 32-bit architecture is available for your applications. So you get efficient process switching and memory management, optional hardware floating-point capabilities and several other features not yet available on most UNIX systems.

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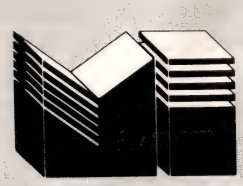
The open-ended VMEbus architecture in our Unistar-32 development system maximizes your potential for high speed data transfer and provides unmatched modular expandability with the use of VMEbus compatible boards. It's a high performance vehicle that can take you anywhere you want to go.

At Mizar, we have a long history of successful product innovation. If you're ready to find out how much our powerful VME/UNIX development system can do for you, call us at **612-224-8941.**



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I'M POWER HUNGRY!

☐ ***Send me all the powerful details on the Unistar-32.***

☐ **Please send more information on your ☐ VME and/or ☐ STD capabilities.**

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

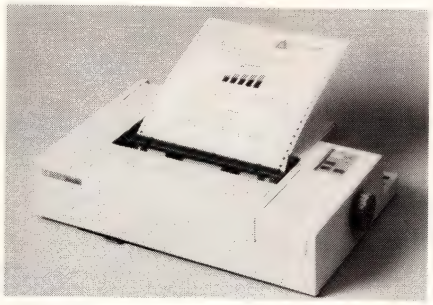
CITY _____ STATE _____

ZIP _____

EDN 122487

Color-graphics printer for PCs produces 167 cps of near-letter-quality text

The HP PaintJet is a color-graphics and near-letter-quality (NLQ) printer for PC users. It produces text and graphics with 180×180-dot/in. resolution and NLQ text at 167 cps. The thermal ink-jet printer prints an average page of text in about 40 sec and a full page of color graphics in about four minutes.



It holds black, yellow, magenta, and cyan inks and mixes them to produce red, blue, and green. The software can mix the primary colors to provide 330 hues. Sixty nozzles transfer the ink to the media, and two disposable cartridges, one for black ink and one for color, contain the nozzles, inks, and electrical printing elements. One cartridge is capable of printing about 1.1 million characters, which translates to about 1100 pages of black text and 180 pages of color graphics.

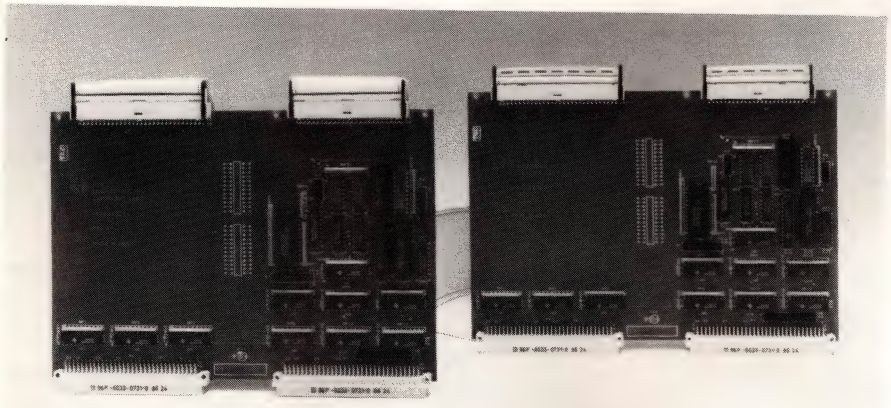
The printer handles Z-fold and cut-sheet paper as well as transparency film in A and A4 sizes. It has 12 character sets, including Roman, Spanish, and German. An RS-232C or CCITT V.24 interface is standard; an HPIB interface is optional. The printer weighs 11 lbs and measures 3.86×17.4×11.89 in. It sells for $1395; black and color cartridges are $27.95 and $34.95, respectively.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 441

Bidirectional VME Bus repeater transfers data at 30M-byte/sec rates

The 2000 Series transfers VME Bus data bidirectionally at 30M bytes/sec. It allows plug-and-play 32-bit address and data expansion of VME systems (for example, the Sun III) while incurring a transfer overhead of 40 nsec. It automatically supports master or slave VME Bus cards in the primary expansion system. The board also performs all necessary system-controller operations, including system-clock-source, bus-arbitration, and bus-timer functions. You can configure the resident bus arbiter to support VME Bus arbitration schemes, or you can disable it if the expansion system already has an arbiter.



The series operates with any combination of release-on-request (ROR) or release-when-done (RWD) requesters in both the primary and expansion systems. This architecture enables more than two VME Bus systems with masters to be linked in a star network. In addition, the series can handle any combination of interrupts and interrupt handlers in either the primary or the expansion chassis. A remote-daisy-chain-return feature automatically expands the interrupt-acknowledge command to include all of the interrupters in the remote chassis when more than two VME Bus systems are linked in a star network. $1995. Delivery, stock to six weeks ARO.

HVE Engineering Inc, 1684 Dell Ave, Campbell, CA 95008. Phone (408) 370-4666. TLX 467956.

Circle No 444

Security system permits developers and VARs to lease their software products

The DS1207 Timekey is a postage-stamp-size security system that enables software developers and publishers to lease their products for a predetermined time period. It features a self-erasing memory, which you can set to expire anywhere from one day to two years after the first access. When the preset time runs out, the software becomes disabled, prohibiting unauthorized use.

The device fits into the company's DS1255 Keyring and works with any IBM PC, PC/XT, PC/AT, PS/2, or compatible. You insert the Keyring into the computer's parallel port, and then plug the Timekey into the Keyring to identify an authorized user and unlock the software. Because the unit dates the software and erases its password-protected memory after a predetermined amount of time, software

publishers and VARs (value-added resellers) can offer their customers pay-as-you-go rentals. A gauge on the Timekey allows the customer to monitor the time remaining on the lease.

Four partitioned memory sections in the device form barriers to ensure security. These consist of a 24-bit section for storing the unalterable communications protocol; a 64-bit section for software-package identification; a 64-bit section for storing 10^{19} passwords; and a 384-bit section that's alterable only after a user presents the correct password. A random-data generator immerses the real password and other information in a stream of meaningless data to prevent unauthorized users from ascertaining the correct password. $10 (100).

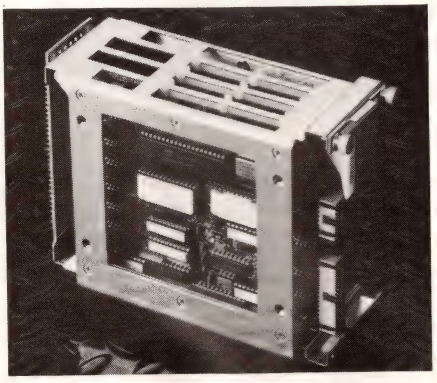
Dallas Semiconductor, 4350 Beltwood Parkway, Dallas, TX 75244. Phone (214) 450-0400.

Circle No 442

Single-board computer for the STD bus uses 7.16-MHz CPU, offers bubble memory

A PC/XT-compatible industrial computer, the System 2 Model 5A is based on a V20 CPU running at 7.16 MHz. The single-board computer contains 128k bytes of system RAM, a ROM disk with Microsoft's MS-DOS 3.2 and a 64k-byte user program space, a 32k-byte PROM containing the BIOS (basic I/O system), a battery-backed clock, an 82C54 counter/timer, an 82C59A interrupt controller, and a PC-compatible serial port.

System-expansion options include floppy-disk drives, 20M-byte hard disk drives, 640k bytes of system



RAM, and the company's 7350 IBM EGA (Enhanced Graphics Adapter) compatible graphics/keyboard card. Other options are available as well. For example, the System 5 Model A supports a 360k- or 720k-byte bubble-memory disk drive from Magnesys Corp and an Arcnet LAN-interface board from Contemporary Control Systems. The Arcnet option permits the user to interconnect units over a 2.5M-bps data link. Including the card, 3-slot card rack, cables, and documentation, the System 5 Model A costs $1045; card only, $850.

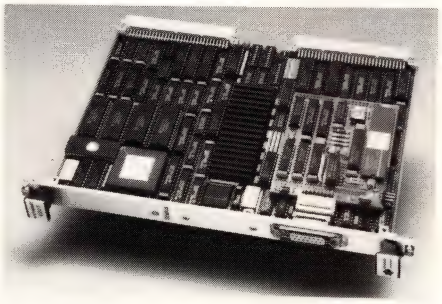
Pro-Log Corp, 2560 Garden Rd, Monterey, CA 93940. Phone (800) 538-9570; in CA, (408) 372-4593.

Circle No 451

VME Bus LAN controller specs data transfers of 30M bytes/sec

The V/Ethernet 4207 Eagle, a VME Bus board for Ethernet communications, is a 16-MHz 68020-based platform capable of DMA transfer rates exceeding 30M bytes/sec. All data paths are 32 bits wide. The node controller enhances its data-transfer capability by decoupling the 68020 and its local 32k×32-byte scratchpad RAM from the data bus, which passes data from Ethernet to the VME Bus via transceivers.

Pipeline registers prevent the controller's Lance communication processor chip from locking up the local data bus as it controls the data flowing to and from Ethernet. A 1k-byte Buspacket FIFO buffer



provides 40-nsec, single-cycle data transfers to the VME Bus from a 512k-byte block of RAM located on the local data bus.

You can store diagnostics and protocol codes in the Eagle's 64k bytes of EPROM. The board also has 32 bytes of nonvolatile RAM for boot routines. The controller can operate in one of three modes: DMA, slave, or mixed. In the DMA mode, the controller is the bus master, executing commands received from the host CPU. In the slave mode, the host CPU on the VME Bus controls the bus and the reads and writes into the controller's RAM. In the mixed mode, the CPU and the controller share control of the bus; the CPU determines where to move the data, and then the controller moves it. $3495 (100).

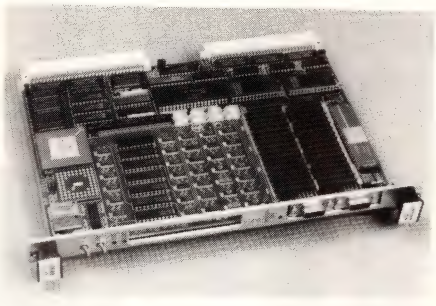
Interphase Corp, 2925 Merrell Rd, Dallas, TX 75229. Phone (214) 350-9000.

Circle No 445

VME Bus single-board computer fills its 68030 cache with no wait states

Suited for use in real-time, multiprocessor, and Unix systems, the PME 68-32 incorporates a 68030 μP and 4M bytes of dynamic RAM. You have the option of adding a 68882 or 68881 math coprocessor. The board's VME Bus interface conforms to IEEE-P1014 Rev D. VME Bus system-controller functions include a 4-level arbiter and a 7-level interrupt handler.

The PME 68-32 operates at processor clock frequencies as high as 33 MHz. The onboard dynamic RAM is dual-ported to the VME Bus and the 68030 μP, but you can configure it in 1M-byte blocks for local access only. The 68030 can fill its internal cache from the dynamic RAM without incurring wait states. Part of the RAM is set aside to



provide a mailbox memory with mailbox interrupt capabilities.

You can also remotely reset the board by addressing a dual-port RAM location. Each of the board's two 32-pin JEDEC-compatible memory sockets can accommodate as much as 128k bytes of EPROM; optionally, one of them can accept a maximum of 32k bytes of static RAM.

The PME 68-32 has two software-programmable synchronous/asynchronous serial ports, which you can configure as either RS-232C or RS-422 interfaces. An expansion connector, which carries the company's PEX 8-bit local-bus-extension interface, allows you to expand the board's functionality. A 16-MHz, 1M-byte version costs approximately $6000.

Plessey Microsystems Ltd, Water Lane, Towcester, Northants NN12 7JN, UK. Phone (0327) 50312. TLX 31628.

Circle No 454

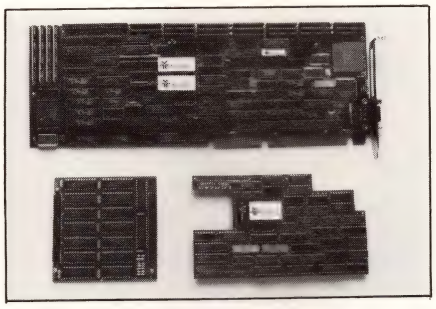
Plessey Microsystems, 1 Blue Hill Plaza, Pearl River, NY 10955. Phone (914) 735-4661. TWX 710-541-1512.

Circle No 455

Graphics-controller board can achieve 8M-pixel/sec line-drawing speeds

The Presto graphics-controller board for IBM PC/ATs and compatibles uses the 32-bit TI 34010 chip running at 50 MHz to process 3 to 5 MIPS. For long vectors, its line-drawing speed is 1.25M pixels/sec, but an optional line-drawing engine accelerates this rate to greater than 8M pixels/sec. The 34010 also permits the programming of features such as software real-time pan and zoom and display-list processing.

The board comes with 512k bytes of dynamic RAM, which is expandable to 4.5M bytes. An additional 2M or 4M bytes of memory is available via a memory-expansion option. The board also has 32k bytes of



ROM. It has two command sets: the Pepe command set, which ensures compatibility with the company's second-generation product; and the Professional Graphics Language (PGL) command set.

Different models provide non-interlaced resolutions of 1280×1024 pixels or 1024×768 pixels. Color choices range from 16 from a palette of 4096 to 256 from a palette of 16.8 million. The Presto board also allows real-time updating of a process-monitoring display and 3-D object rotation. Prices vary from $2395 for versions with 1024×768-pixel resolution and 16 colors, to $3150 for models with 1280×1024-pixel resolution and 256 colors. The line-drawing-engine option costs $425.

Vectrix Corp, 2606 Branchwood Dr, Greensboro, NC 27408. Phone (800) 334-8181; in NC, (919) 288-0520. TLX 574417.

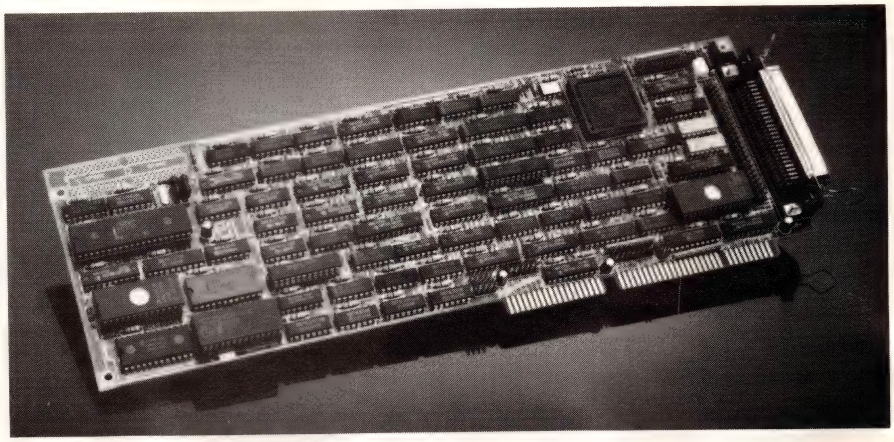
Circle No 443

PC/AT bus adapter transfers data to host at 10M bytes/sec

The AHA-1540 SCSI host adapter board for the PC/AT sends bursts of data across the host bus at rates as high as 10M bytes/sec. Furthermore, it performs 2M-byte/sec asynchronous transfers and 5M-byte/sec synchronous transfers to SCSI bus peripherals.

The board has a mailbox architecture to implement multitasking in the I/O subsystem. The host CPU communicates with the host adapter through 255 memory-resident mailboxes. Each mailbox represents a task currently active in the I/O subsystem. The host adapter only interrrupts the host CPU on completion of a task. In MS-DOS applications, the host adapter emulates a standard PC/AT bus disk controller.

The board can also operate as a



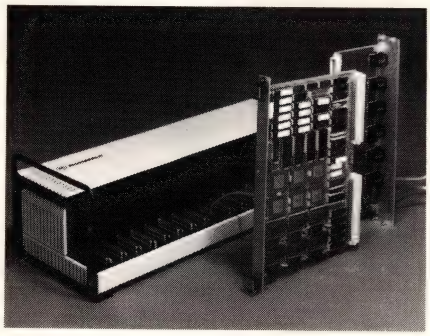
PC/AT bus master. The SCSI transfer rate results from the company's AIC-6250 SCSI protocol IC residing on the board. The host adapter includes disconnect/reconnect, arbitration, and command-linking and -queuing features. It also can recognize synchronous and asynchronous peripherals concurrently tied to the bus. $285 (100).

Adaptec Inc, 580 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 432-8600.

Circle No 448

Single controller board allows 96 RS-232C devices to connect to VME Bus

The Deltalink controller board provides an inexpensive means of connecting a VME Bus system to as many as 96 different RS-232C devices. It consists of three units: the Deltalink Hub (MVME336), which is a double-height VME controller board; the transition module (MVME751), which mounts on the VME Bus; and the Deltalink Server (SYS336M16-1), which can be a maximum of 800 ft from the VME system. The Deltalink Hub contains six Motorola MC68605 controller chips that interface with the transition module.



The controller board permits 12 concurrent DMA channels to operate between the controller chips and the 128k-byte, onboard global RAM. It also provides 32-bit-wide transfers over the VME Bus and selectable 24- and 32-bit addressing. The transition module provides six output drivers for unshielded twisted-pair wiring. It is intended to drive a maximum of six remotely located Servers. The Servers concurrently support 16 active RS-232C ports at rates to 19.2k bps.

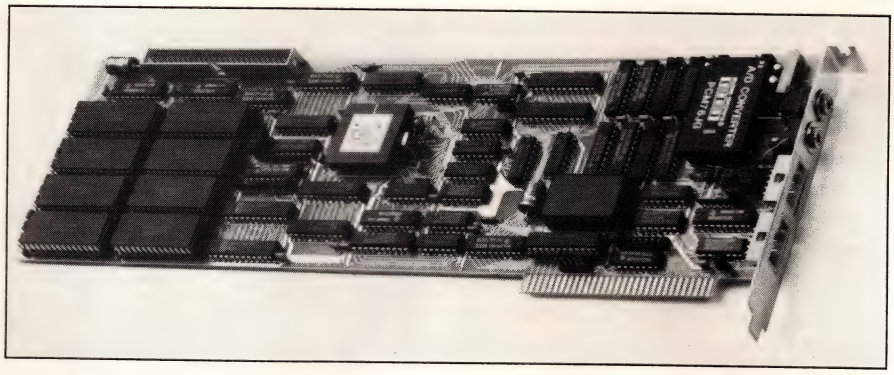
All transmissions between the Hub and Servers are 1M bps full duplex. Characters are synchronously transmitted in HDLC-encoded (high-level data-link control) packets with cyclic redundancy checks. Together the MVME336 and the MVME751 cost $1800; the SYS336M16-1 costs $1800.

Motorola, Microcomputer Div, 2900 S Diablo Way, Tempe, AZ 85282. Phone (800) 556-1234.

Circle No 446

System for developing TMS320C25 code runs on IBM PCs and samples at 50 kHz

The TMS320C25 Development System is a general-purpose DSP system for IBM PCs, PC/XTs, PC/ATs, and compatibles. Using the TI TMS320C25 DSP processor running at 40 MHz, the system can serve as a development tool or an application board. It comes with 16-bit A/D and D/A converters, which can achieve sample rates reaching 50 kHz, and an onboard sample-and-hold function.



It also comes with 16k words of 35-nsec (zero wait-state) RAM, expandable to 64k words of program RAM and 64k words of data RAM. In addition, the board has a 12-port expansion bus that provides data, address, and control links to external hardware.

Monitor software handles single-step, breakpoint, or full-speed operation. The software, resident on the PC host, can take data from the TI Macro Assembler/Linker and download it to the board. The system can perform signal processing that's independent of host operation.

You can order TI's TMS320C25 Macro Assembler/Linker and the company's Signalink320 data-acquisition separately. The system, monitor software, and documentation sells for $2595.

Spectrum Signal Processing Inc, 240 H St, Blaine, WA 98230. Phone (800) 663-8986; in WA, (604) 438-7266.

Circle No 450

RISC-based color-graphics workstation sustains operation of 10 MIPS

The Hitech-10 desktop workstation is based around MIPS Computer Systems' 16.67-MHz R2000 RISC chip set and is capable of a sustained throughput of 10 MIPS. It has an 8-plane, 1280×1024-pixel image memory that can simultaneously display as many as 256 colors from a palette of 16.7M. A 16- or 20-in. color monitor is also included.

The workstation comes with either Unix 4.3 BSD or Unix System V, and either an X-Windows (version 11) or News distributed window management system. Because it incorporates these industry-standard window management systems, together with optimizing compilers for C, Pascal, and Fortran, the task

of porting CAE software onto the workstation is easier. Networking facilities include Ethernet/Cheapernet interfaces that operate with TCP/IP and NFS protocols.

The Hitech-10 has 8M bytes of RAM (expandable to 40M bytes), an MS-DOS-compatible floppy-disk drive, and hard-disk-drive options that provide 95M to 320M bytes of internal hard-disk storage. You can also install a 60M-byte tape cartridge. An IBM PC/AT-compatible expansion bus provides internal expansion facilities. The Hitech-10 is targeted at OEMs and VARs; you can expect end-user prices starting at £25,000.

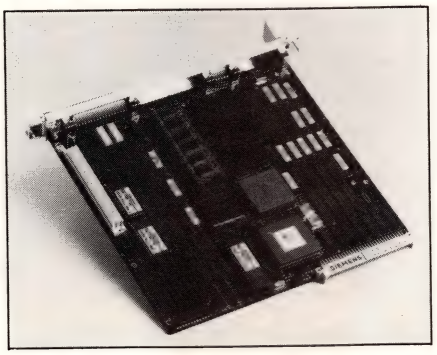
Whitechapel Workstations Ltd, 75 Whitechapel Rd, London E1 1DU, UK. Phone 01-377 8680. TLX 885300.

Circle No 456

CPU cards for Multibus II systems allow 32-bit user expansion

The OSM-B17 and the OSM-B37 Multibus II CPU boards feature a proprietary OME (onboard module expansion) interface, a 32-bit bus that allows you to plug in various piggyback boards to extend local memory or increase board functionality. You can design your own piggyback modules or use the company's standard modules.

The OSM-B17 has an 8-MHz 80186 μP, an 82258 advanced DMA controller, and 1M bytes of onboard dynamic RAM. Optionally, you can dual-port 512k bytes of the dynamic RAM to the 80186 and to the Multibus II PSB bus. The OSM-B37 has a 20-MHz 80386 μP, an 82258A advanced DMA controller, a 64k-byte zero-wait-state static-RAM cache,



and 2M bytes of onboard dynamic RAM. You can configure the RAM as dual-ported memory.

Both boards incorporate a message-passing coprocessor to interface to the Multibus II PSB bus, and both have resident firmware to support Multibus II's built-in self-test and power-on diagnostics. Also, they can accommodate an optional math coprocessor. I/O facilities include serial ports, SCSI-bus/general-purpose parallel ports, and Centronics-compatible ports. JEDEC-compatible memory sockets allow you to install as much as 256k bytes of EPROM.

Available piggyback modules include interface boards for the company's AMS and SMP buses, an 8M-byte memory board, and a graphics board. OSM-B17, around DM 5000; OSM-B37, around DM 11,000; piggyback modules start at DM 500.

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 457

Communications protocol interface connects VAXs to the Defense Data Network

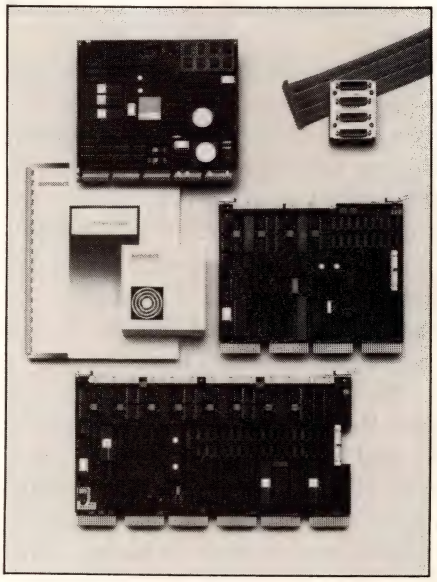
The CPI 9000 communications protocol interface consists of both hardware and software and connects VAX computers to the Defense Data Network (DDN). It is certified by the Defense Communications Agency. An intelligent front-end processor offloads the standard or basic X.25 network-level communication tasks from the host.

You can configure the board with a maximum of 512k bytes of RAM. The CPI 9000 uses the Z8030 SCC multiprotocol serial-communication chip; two serial ports can simultaneously handle line speeds reaching 64k bps. Six additional lower-speed serial ports are also available.

The interface incorporates all the layers of the DoD protocol architecture into three software levels. The user level executes the application layer, which consists of Telnet, FTP, and SMTP. The kernel level performs the transport and internet layer protocol (TCP/IP). The board level implements the packet, frame, and physical levels of X.25. An X.25 DDN multiport system for the Q Bus with an Ultrix/32M operating system costs $5500.

Simpact Associates Inc, 9210 Sky Park Ct, San Diego, CA 92123. Phone (619) 565-1865.

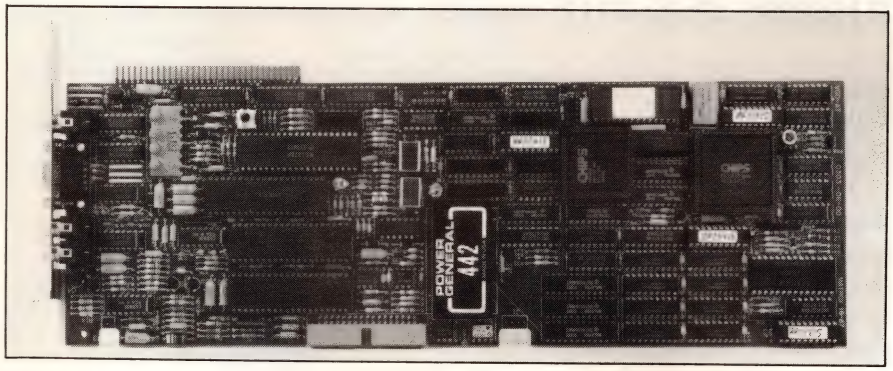
Circle No 452



EGA/VGA video-graphics-overlay board features 720×480-pixel resolution

The VGO-AT is an IBM PC/AT-compatible graphics and text controller board with overlay capability. This IBM EGA/VGA- (Enhanced Graphics Adapter/Video Graphics Array) compatible board has 256k bytes of RAM, allowing it to display 16 colors from a palette of 64 and to achieve resolutions of 640×480 or 720×480 pixels.

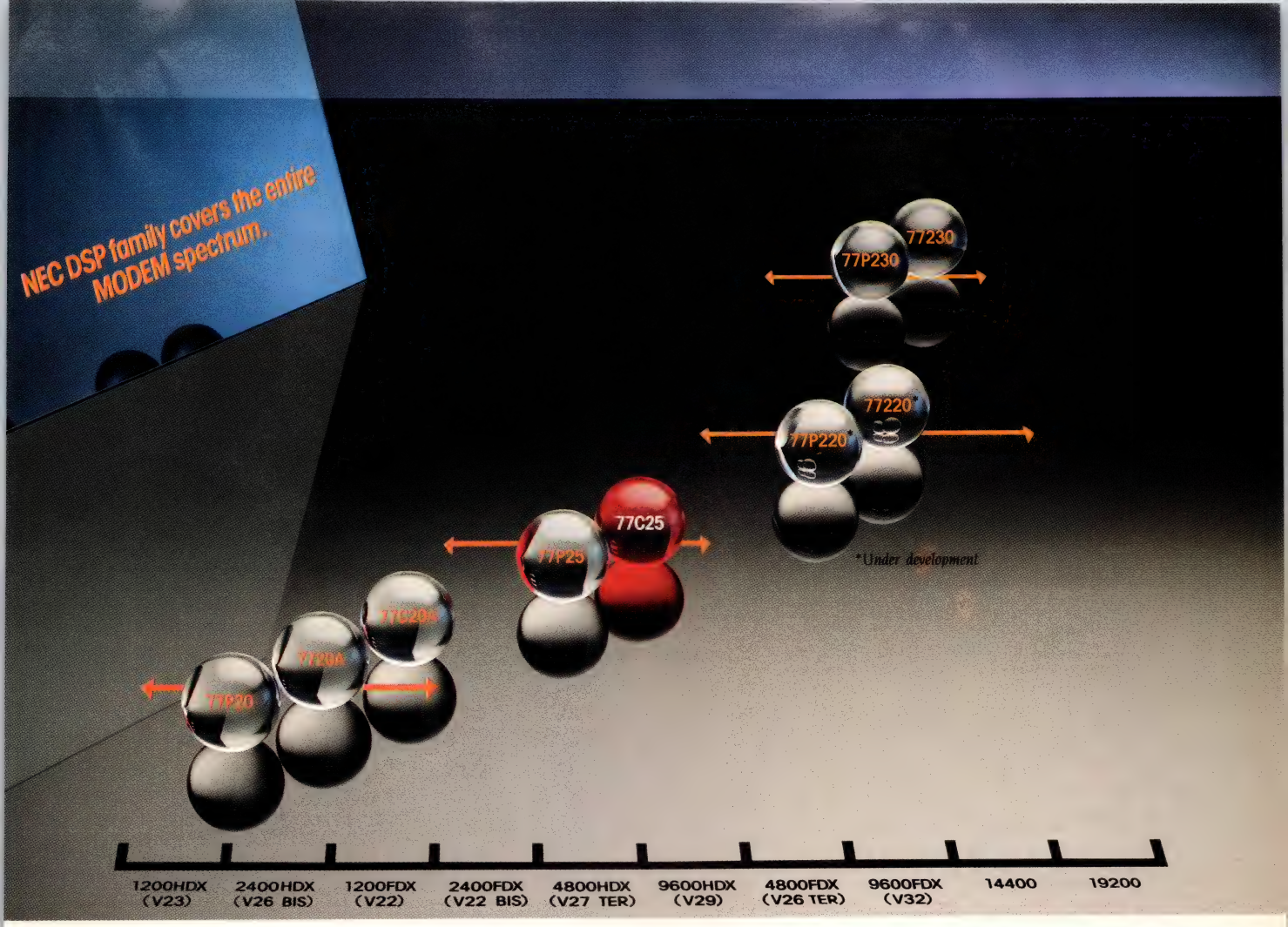
The host CPU writes ASCII characters and bit-mapped graphics to the board's memory. The board then superimposes the memory contents onto a video signal from an external source, such as a video-disk player, a video machine, or a video camera. The VGO-AT composes the signal in such a way that the external video signal rests behind the graphics and alphanumeric characters.



The controller board's NTSC output is capable of driving large projection screens. The board converts the NTSC input signal to an RGB input signal using digital-signal processing and comb-filter techniques, and it is capable of driving fixed-sync or multisync RGB monitors. It also provides an RGB-to-NTSC encoder, which allows NTSC overlay output for broadcast applications. The VGO-AT is compatible with the US Army's EIDS video-disk-based training system and costs $1495.

Matrox, 1055 St Regis Blvd, Dorval, Quebec, H9P 2T4, Canada. Phone (514) 685-2630. FAX (514) 685-2853.

Circle No 453



Calling all modems NEC introduces an enhanced 16-bit DSP

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The enhanced 77C25 gives you twice the performance of the 77C20A. Twice the speed—122ns. More than twice the memory capacity—2K × 24 instruction ROM, 1K × 16 data ROM, and 256 × 16 data RAM. Yet the same power consumption—0.2W max.

You can replace two 77C20As with one 77C25—with little modification in peripheral circuits. Available in 28-pin DIP or 44-pin PLCC. The 77C25 is both pin- and software-compatible at the source level with the 77C20A. Development tools are available off the shelf and the EPROM-version 77P25 is coming soon.

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	The Netherlands Tel:040-445-845. Telex:51923 NEC B NL.
	Sweden Tel:08-732-8200. Telex:13839 NECSCAN S.
	France Tel:1-3946-9617. Telex:699499 NEC EF.
	Italy Tel:02-6709108. Telex:315355 NECEIT I.
	UK Tel:0908-691133. Telex:826791 NECUK G.
■ Asia	Hong Kong Tel:3-755-9008. Telex:54561 HKNEC HX.
	Taiwan Tel:02-522-4192. Telex:22372 HKNEC TP.
	Singapore Tel:4819881. Telex:39726 NECES RS.
■ Oceania	Australia Tel:03-267-6355. Telex:AA38343 NECBCD.

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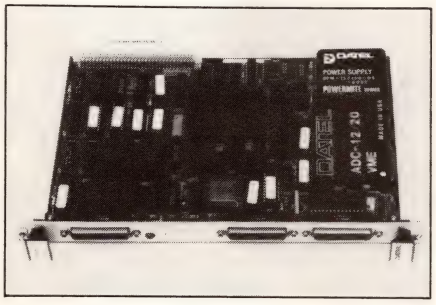
NEC

VME Bus analog-input board offloads data-acquisition processing from host

The DVME-601, an analog-input board for the VME Bus, uses an 8-MHz 68010 CPU and 64k bytes of private RAM to offload VME Bus host processors of all A/D scanning and math processing. The card accepts 16 single-ended or eight differential analog-input channels. Four A/D-converter modules provide resolution choices of 12, 14, or 16 bits and conversion speeds as fast as 4 μsec.

The board provides samples to the local memory at a rate of 170,000 samples/sec. Full-scale inputs over the range of 0 to 5V, 0 to 10V, and ±5 or ±10V are jumper selectable. An onboard instrumentation amplifier is resistor programable over a gain range of 1 to 1000.



The card also has 64k bytes of EPROM, which is expandable to 128k bytes, and 64k bytes of dual-ported RAM, which it shares with the VME Bus. The DVME-601 uses the dual-ported RAM to transfer data blocks, command/status information, bidirectional interrupts, and programs to be downloaded to the local RAM for execution.

A 68901 peripheral controller chip provides five external-I/O or local-interrupt bits, an RS-232C port, and four 8-bit counter/timers. The user may run his own math programs on the board while the host performs other tasks. Operating as a VME bus slave, the DVME-601 occupies 64k bytes of host memory. A 12-bit, 20-μsec model costs $1995.

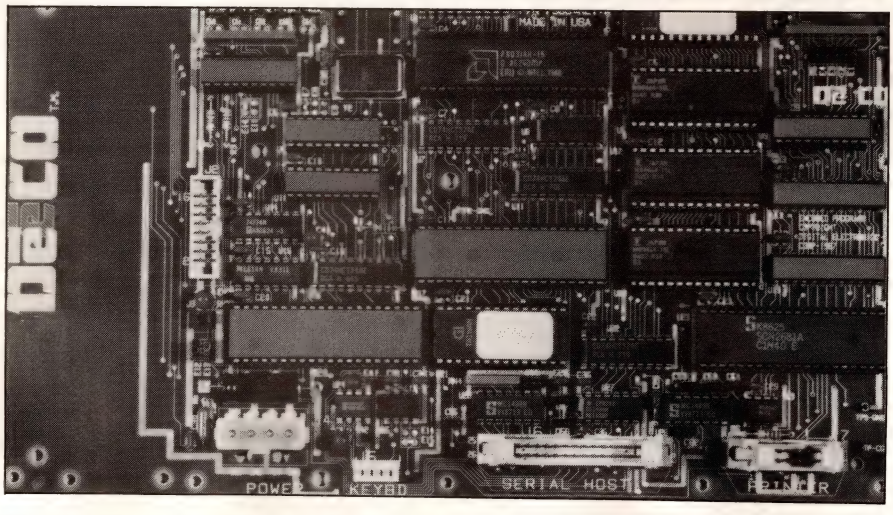
Datel, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. TWX 710-346-1953.

Circle No 447

Controller for flat-panel displays emulates operation of VT220 terminal

The C220 is a controller board for electroluminescent and ac plasma flat-panel displays. It emulates a VT220 terminal capable of driving 80 columns and 25 lines of text on 512×256-pixel, 640×200-pixel, and other matrix displays. The board includes interfaces for an RS-232C host port, a keyboard port, and a printer port. Multiple character sets for ASCII, multinational, graphics, and Hebrew, as well as four user-definable character sets, are standard.

The card can operate in two modes. The terminal mode permits a keyboard connected to the controller to bring the terminal setup parameters to the screen. Once the parameters are set, you can save them in memory for future power-ups. The controller mode permits the user to control the display from the host CPU. You can change the default parameters and store them in the controller memory for future power-ups. The printer port is bidirectional and can also function as a modem interface. $595 (100).



Digital Electronics Corp, 31047 Genstar Rd, Hayward, CA 94544. Phone (415) 471-4700. FAX (415) 489-3500.

Circle No 449

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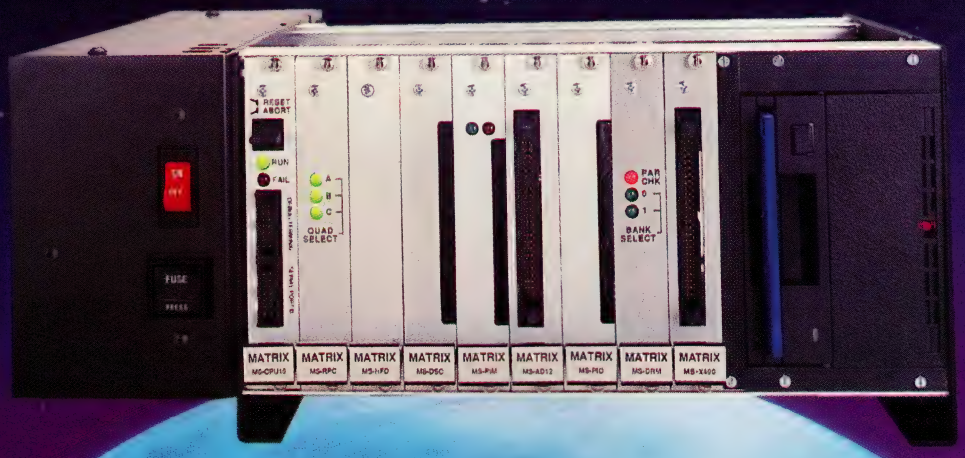

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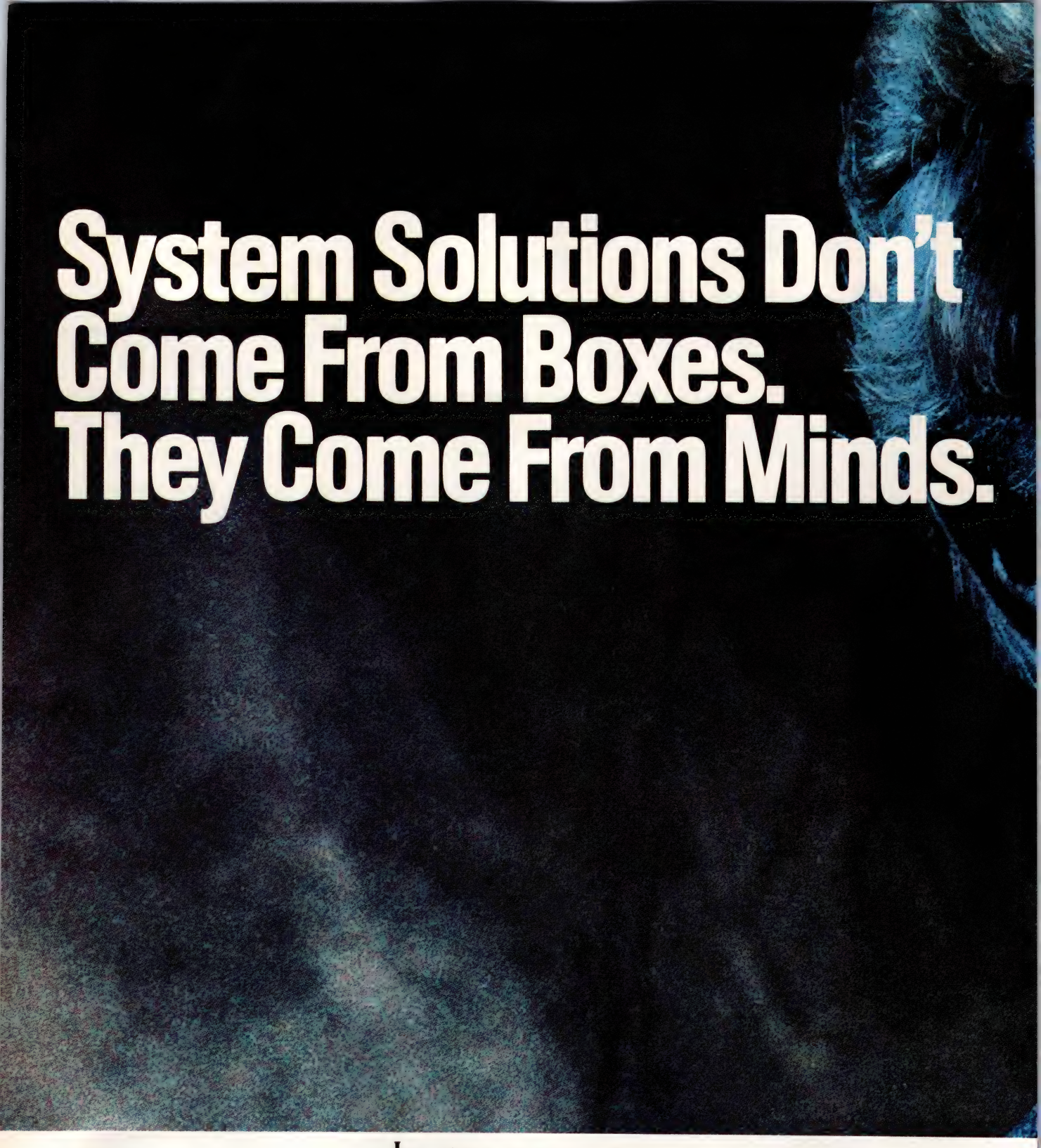

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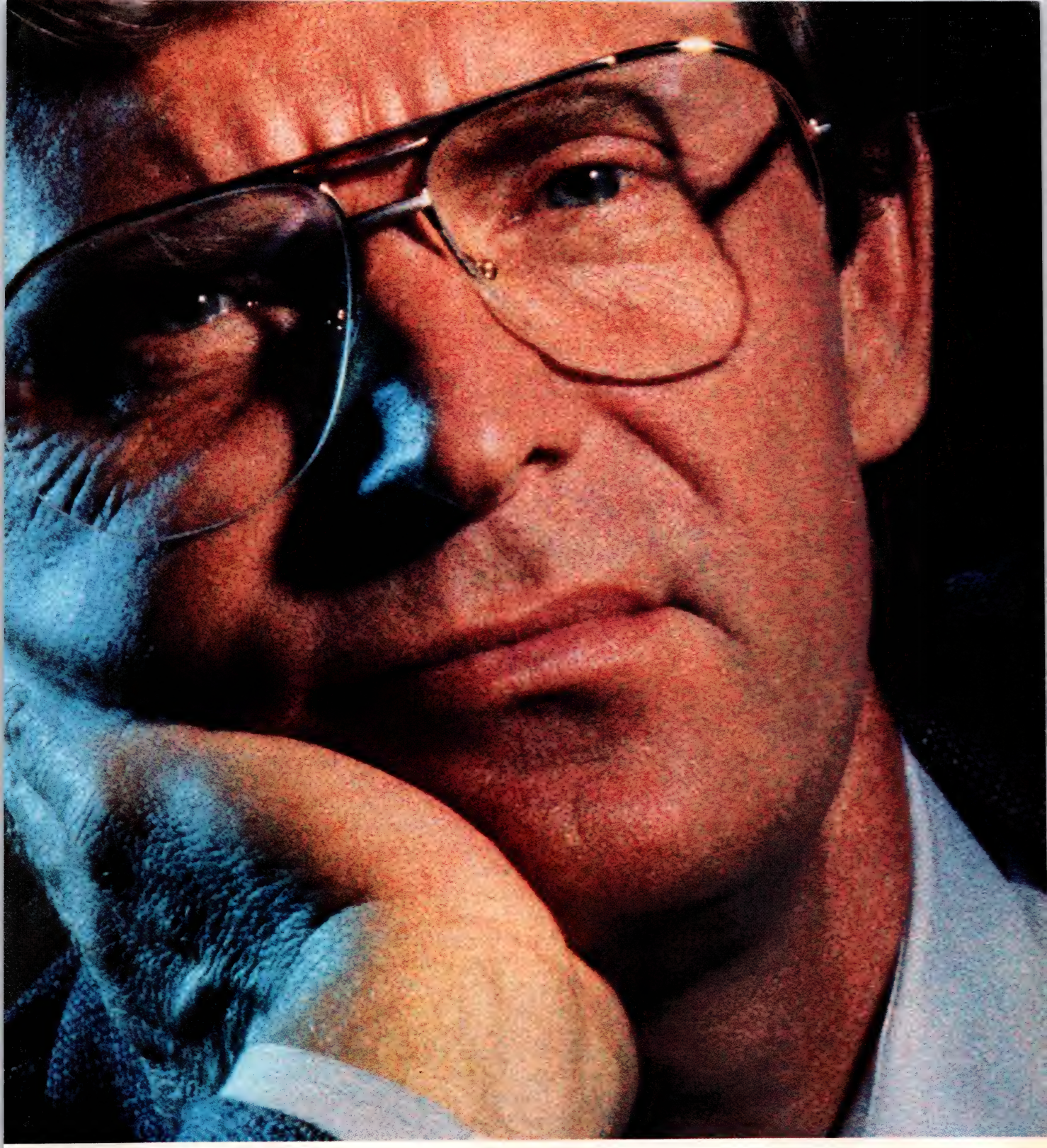

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CIRCLE NO 117

© Copyright 1987 by System Industries, 560 Cottonwood Drive, Milpitas, CA 95035. *In California (408) 432-1212.

COLOR PRINTER

The 4/62 is a color dot-matrix printer designed for high-volume, letter-quality printing applications. Like the vendor's 4/66 unit, it can switch automatically from cut sheets to fanfold paper, without your having to remove the paper from the tractors. An 18-wire staggered printhead lets the printer produce letter-quality characters at 120 cps in a single pass. Its resolution is 60×18 dots/character; its noise level is below 55 dB.

The device prints in seven colors, and you have the option of employing as many as six of the 20 available fonts on one page. The 15.4-in. printable width permits the processing of legal documents, spreadsheets, and B-size landscape paper. The printer is compatible with the IBM Graphics Printer and the Epson JX 80. $2160.

Honeywell Bull Italia, 120 Howard St, Suite 800, San Francisco, CA 94105. Phone (415) 974-4340.

Circle No 625

RASTER DISPLAYS

The GR-4400 Series furnishes 2-D and 3-D raster-display systems. Each model includes a 19-in. noninterlaced monitor, a 68000-based μP with custom-designed gate arrays, and a keyboard. They each have two color-display modes. The GR-4406 performs 2-D wireframe transformations at a rate of 300,000 vectors/sec. The GR-4416 performs 3-D wireframe transformations at 400,000 vectors/sec and features a memory scheme that permits dynamic updating during real-time operations.

The basic unit comes with 0.5M bytes of dynamic RAM, which is expandable to 4.5M bytes in the GR-4406, and to 6.5M bytes in the GR-4416. In normal display mode, each system can display a 1280×1024-pixel image with as many as 1024 colors from a palette of 16 million. In full-color mode, each model can display the full 16 million colors but with a resolution of 640×512 pixels. Each display's communication interfaces include Ethernet, Cheapernet, 16-bit parallel, RS-232C, and RS-449. Two software application packages are available. $20,950 to $52,000.

Seiko Instruments USA Inc, 1130 Ringwood Ct, San Jose, CA 95131. Phone (408) 943-9100.

Circle No 626

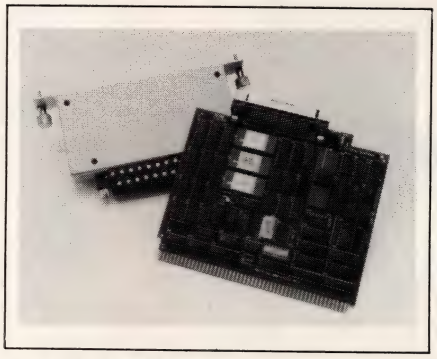
ANSWERING MACHINE

The CAM turns any IBM PC/XT, PC/AT, or compatible PC into a smart telephone-answering machine, according to the manufacturer. Using its onboard μP, the board digitizes the caller's voice and stores it on the computer's hard disk. The device is fully operational even when the PC is running other programs. The board requires the following devices for operation: one expansion slot; MS-DOS or PC-DOS version 2.1 or higher; a hard-disk drive; a floppy-disk drive for initial program loading; a 384k-byte RAM with at least 256k bytes of user memory; an 80-column display and adapter; a standard telephone line capable of Touch Tone operation; and a standard Touch Tone telephone.

The board uses a proprietary voice-compression algorithm to store 1 sec of speech in 3k to 3.5k bytes of disk storage space. Some of the features include multiple-voice mailboxes, which allow you to have your own mailbox (with passwords for privacy); message forwarding, which allows the device to call you at another location and deliver the message as it is received; call transfer, which allows you to transfer calls to another extension instead of leaving a message; and remote operation, which lets you change almost any system parameter from a remote Touch Tone telephone. $349.

The Complete PC Inc, 521 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 434-0145.

Circle No 627



A/D BOARD

The AD300 is an A/D converter board for the HP 9000 Series 200/300 workstations. The board allows data acquisition from 32 single-ended or 16 differential analog inputs. It has a 4-channel simultaneous sampling capability with 12-bit resolution and a throughput of 200 kHz. A μP controls all onboard operations, thus unburdening the host. A 64k FIFO buffer further reduces the host's load.

An onboard channel sequencer allows the board to store a list of as many as 2048 states, each with its own channel, mode, and gain specification. An 8-bit digital output port gives you control of external instrumentation. Two external trigger lines are provided to meet specific application requirements. One uses a rising-edge signal to initiate sampling, and the other sets a voltage level for input triggering in 20-mV increments within the ±5V input voltage range. The board is programmable, using HP's GPIO protocol. $1900.

Infotek Systems, 1045 S East St, Anaheim, CA 92805. Phone (714) 956-9300.

Circle No 628

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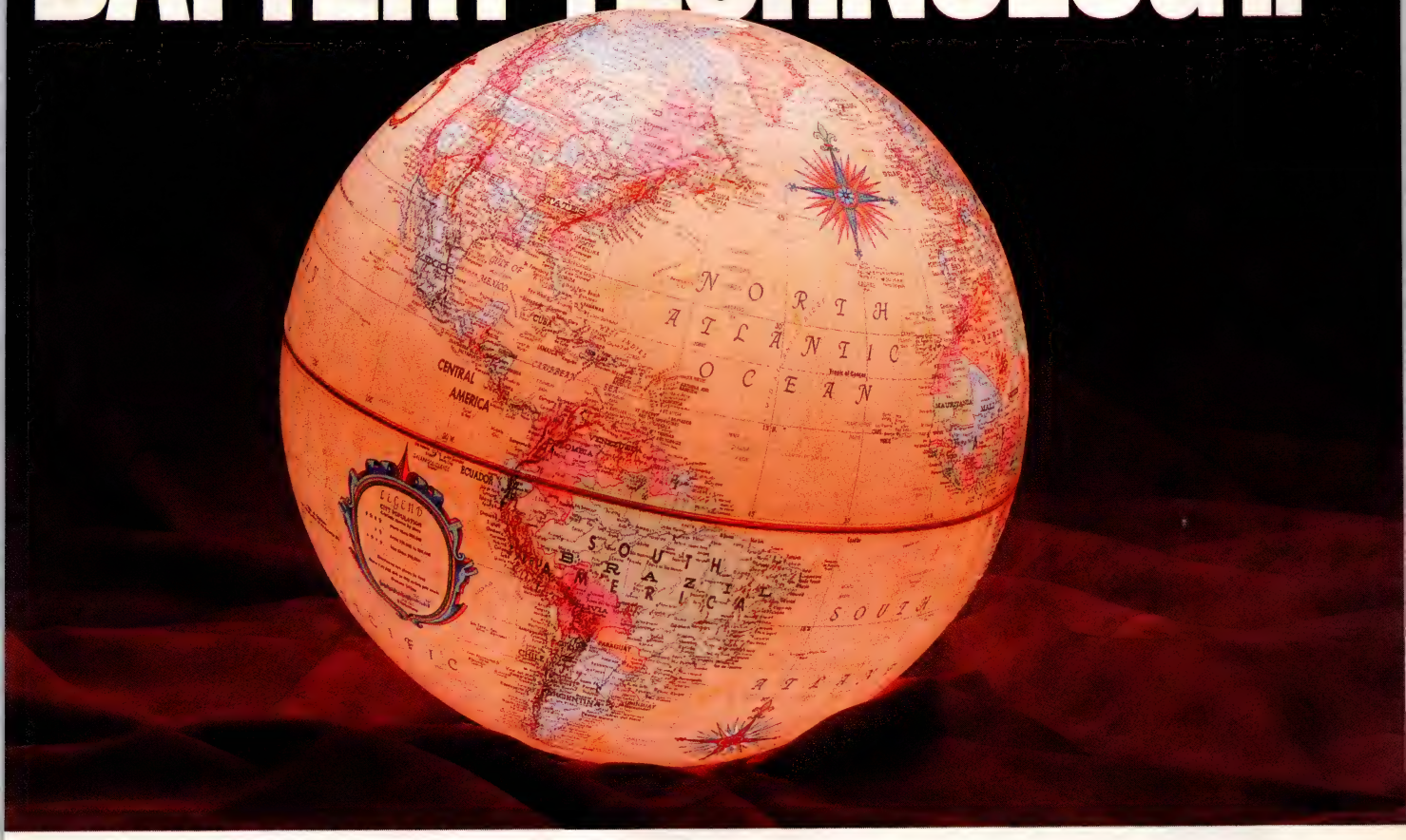

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CIRCLE NO 70

VME BUS MODULE

The XVME-682 VME Bus PC/AT processor module is a 2-card set that brings PC/AT compatibility to the VME Bus. It has a 10-MHz 80286 μP and can perform as a VME Bus master and interrupt handler. A PC/AT bus expansion is optional at the VME Bus P2 connector. The board's features include 1M to 4M bytes of dual-port RAM, a ROM-resident BIOS, a battery-backed time-of-day clock, facilities for an 80287 math coprocessor, two serial ports, a Centronics parallel interface, a keyboard interface, and a watchdog timer.

In addition, the board has a hard/floppy-disk-drive controller and an EGA/CGA (Enhanced Graphics Adapter/Color Graphics Adapter) graphics controller. A local bus unites the 2-board architecture and allows direct communication with EGA/CGA or disk-drive-controller circuitry without tying up the VME Bus. The board can address its local memory as well as 16M bytes (A24) of VME Bus address space. $2800.

Xycom, 750 N Maple Rd, Saline, MI 48176. Phone (313) 429-4971.

Circle No 633

PROTOCOL CONVERTER

The SmartNet 5250/T protocol converter allows as many as seven asynchronous devices to be connected to IBM Systems 34/36/38 or 5294 minicomputers. It attaches to the computer via a standard 2-conductor shielded twinax cable and can be located as far as 5000 ft away. The device supports more than 45 asynchronous terminal types, including IBM 3161/62/63/64, DEC VT100/VT102/VT220, C Itoh 7103, Lear Siegler, Adds Viewpoint and Viewpoint 60+, Hazeltine, Televideo, and Wyse.

Video and editing features let you use 132-column×27-line asynchronous displays to emulate IBM 3180 Model 2 terminals. The unit also supports seven colors, thus allowing asynchronous color displays to emulate IBM 5292 Model 1 terminals. The converter can run with parallel and serial printers such as IBM's Proprinter XL, Quietwriter 2, Wheelprinter, 3812 Pageprinter, HP LaserJets, and Okidata or Epson FX 80/85. $2595.

PCI Inc, 26630 Agoura Rd, Calabasas, CA 91302. Phone (818) 880-5704.

Circle No 635

DATA TRANSPORTER

The IV-3272 FSDT (full-speed data transporter) is a data module for the VME Bus. It allows data transfers across the bus at 40M bytes/sec. The module achieves this speed by using 32-bit transfers, address pipelining, and slave modules that return the DTACK command within 30 to 50 nsec. You specify transfers by writing a software routine (a transfer parameter block, or TPB) to an onboard location.

The TPB includes information on the source, destination, type, and length of the transfer. The TPB may also contain a pointer to the next TPB, thus allowing sequential transfers. Flexible bus-release modes make the transporter useful in multiprocessor systems as a dedicated message passer. The board also contains a TMS32010 DSP chip, which can analyze data as transfers occur. $2365 (100).

Ironics Inc, 798 Cascadilla St, Ithaca, NY 14850. Phone (607) 277-4060. TLX 705742.

Circle No 634

2400-BPS MODEM

The Practical Modem 2400 SA is a 2400-bps stand-alone modem that is fully Hayes compatible. It can store as many as 10 telephone numbers for automatic dialing and has features such as an automatic answer mode, echoplexer, speaker volume, and half- or full-duplex operation. You select the number of times the phone rings before the modem answers. The dial features include Touch Tone or pulse; programmable pause interval; and originate call from answer mode.

The modem meets the following standards of operation: CCITT at 2400 bps, Bell 212A at 1200 bps, and Bell 103 at 300 bps. It operates with the Hayes command set, which allows a computer or terminal to control the modem, using communications software through an RS-232C interface. The modem measures 10.5×5.5×1.3 in. and is designed to fit under a telephone. $239.

Practical Peripherals, 31245 La Baya Dr, Westlake Village, CA 91362. Phone (818) 991-8200. TWX 910-336-5431.

Circle No 636

CRT TERMINAL

The CIT310 DEC-compatible terminal can connect to two hosts for simultaneous operation. In effect, it acts like two complete CIT224 terminals. Two separate cable connections allow dual sessions between a central DEC VAX or MicroVAX II computer and a remote computer connected via a modem or a LAN. In the dual-session mode, the screen can be split horizontally, allowing you to select the percentage of display devoted to each session. Each host can have an independent screen display of 24 rows, and pressing the mode/session key allows you to toggle between screens. One session can display a 132-column mode, enabling you to view spreadsheet data while the other session is in an 80-column mode for word processing.

The terminal provides 1k byte of nonvolatile memory per session for storing 180 programmable functions that are accessible through 45 function keys. The device can locally store four pages or 100 lines of screen information, and it can allocate the memory to one session or

split it evenly for a dual session. Viewports let you display small sections of memory; a review mode is available for line-by-line scrolling. The terminal has a 14-in. diagonal flat-screen display in soft white, amber, or green phosphors. The DIN keyboard comes with 108 keys. $749.

CIE Terminals Inc, 2505 McCabe Way, Irvine, CA 92714. Phone (800) 624-2516; in CA, (714) 660-1421. TWX 910-595-1103.

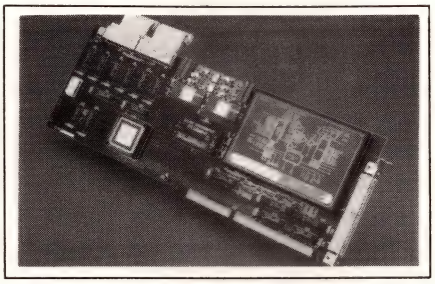
Circle No 637

CD ROM

The XM-3100B CD ROM optical-disk drive provides 680M bytes of storage space and comes in a 5¼-in. form factor with a height of 1¾ in. It has an average access time of 400 msec. Its stereo-audio capability lets you use audio data to supplement text and image data; it has a SCSI interface and uses an interchangeable Sony cartridge. Read operations can be performed with or without an error-correction code. When an ECC is used, the bit error rate is $<1\times10^{-12}$. Less than $600 (100).

Toshiba America, Disk Products Div, 9740 Irvine Blvd, Irvine CA 92718. Phone (714) 583-3108.

Circle No 638



I/O BOARDS

The DT2841 Series is a set of analog and digital I/O boards for the IBM PC/AT. The series provides 12- or 16-bit A/D inputs and two 12-bit D/A outputs. The boards use an external I/O port (called DT-Connect) to transfer data to a processor board (such as the company's DT7020 array processor); this method avoids using the slower IBM PC/AT bus.

The boards in the series differ in their analog input characteristics and throughput speeds. Inputs can be either single-ended or differential. A/D throughputs can range from 40 to 750 kHz. The two D/A channels can provide either single or dual simultaneous outputs at rates as high as 130 kHz/channel. In addition, each board contains 16 digital I/O lines organized as two 8-bit ports. Each port can be set for input or output transfers. Prices range from $1450 to $2995, depending on the model.

Data Translation Inc, 100 Locke Dr, Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

Circle No 640

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- iLBX™ memory expansion bus
- Two serial ports
- Optional 68881 floating point coprocessor
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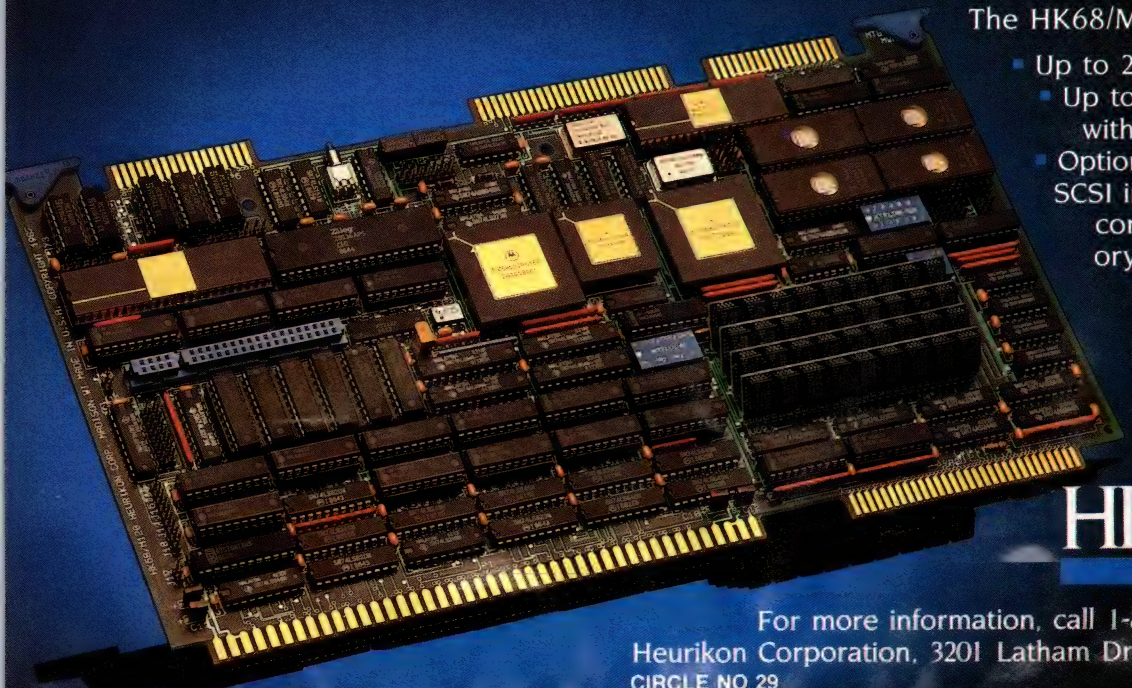


HEURIKON CORP

For more information, call 1-800-356-9602, Ext. 409
Heurikon Corporation, 3201 Latham Drive, Madison, WI 53713
CIRCLE NO 29

CPU CARD

The TP23MII Multibus-II CPU card is based on a 68020 μP and an optional 68881 math coprocessor and is available in two versions. The TP23MII/U4 has a 68851 PMMU (paged memory-management unit) and 4M bytes (expandable to 16M bytes) of onboard dynamic RAM, so it's suitable for use as a Unix programming environment. The TP23MII/R1, which has only 1M byte of dynamic RAM and no PMMU, is best suited to real-time applications.

The board has two DMA controllers, one of which controls data transfers via the Multibus-II interface's message-passing coprocessor; the other controls data transfers via the board's SCSI and iLBX-II interfaces. The board also has an iSBX interface, and you can optionally have an onboard Ethernet interface with its own DMA capabilities.

Additional onboard facilities include sockets for as much as 256k bytes of EPROM, a battery-backed 2k-byte static RAM and real-time clock calendar, and six RS-232C I/O ports. The board may optionally be supplied with the Unix System V.2 operating system or a VRTX real-time kernel. Software to link VRTX and Unix, using Multibus-II transport protocols, is available. TP23MII/U4, £4800; TP23MII/R1, £3300.

Tadpole Technology plc, Titan House, Castle Park, Cambridge CB3 0AY, UK. Phone (0223) 461000. TLX 818152.

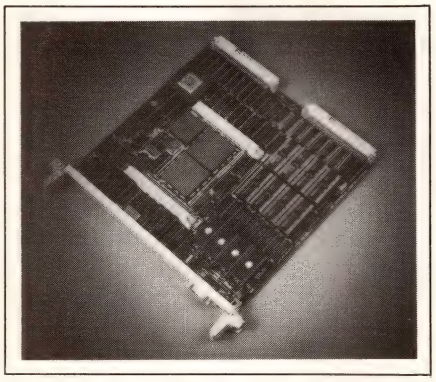
Circle No 668

Tadpole Technology Inc, 6747 Sierra Ct, Suite K, Dublin, CA 94568. Phone (415) 828-7676.

Circle No 669

CPU CARD

The M-CP386/016 is a 32-bit Multibus-II CPU card based on an 80386 μP and an 82380 DMA controller, both of which operate at a clock frequency of 16 MHz. You can optionally add a 16-MHz 80387 math



coprocessor. The board has eight JEDEC-compatible 32-pin sockets for as much as 1M byte of zero-wait-state static RAM, and four 32-pin sockets that accept as much as 1M byte of EPROM. Additional onboard functions include two RS-232C I/O channels, and a real-time clock/calendar.

A memory-expansion connector allows you to add as much as 8M bytes of memory, using 1M-, 2M-, or 4M-byte piggyback memory-expansion modules. You can also provide additional memory, or I/O expansion, via the board's P2 connector, which carries the company's cCBX expansion interface. The board's Multibus-II PSB interface incorporates a message-passing coprocessor and supports the Multibus-II BIST (built-in self-test) and interconnect space functions. £2950.

Concurrent Technologies Ltd, Fairfax House, Causton Rd, Colchester, Essex CO1 1RJ, UK. Phone (0206) 42996. TLX 94012560.

Circle No 664

Concurrent Technologies Inc, 25401 Cabot Rd, Suite 206, Laguna Hills, CA 92653. Phone (714) 768-3332. TLX 989159.

Circle No 665

GRAPHICS BOARD

The OPAC graphics board combines two AMD QPDM quad pixel dataflow-manager ICs and a 2M-byte frame buffer to provide a high-resolution graphics subsystem for VME Bus systems. The board allows you to simultaneously display as many as 256 colors from a palette of 16.8M colors, using a 1280×1024-pixel resolution display with a refresh rate of 60 Hz. By cascading three OPAC boards and using VME Bus broadcast data transfers, you can program all the QPDMs in parallel. This configuration allows you to operate with 24 bits/pixel without slowing graphics operations.

Other features of the board include a text update rate in excess of 10,000 characters/sec and BitBlt operations at pixel rates in excess of 16M pixels/sec that allow you to build an entire screen in 16 msec. Graphics commands to the board are queued in a 1k-byte onboard FIFO buffer, relieving the host processor of the necessity to wait for the board to become available for new graphics commands. Software support for the board includes the company's QPAC software-development tools, and high-level graphics packages such as GKS. Version with one QPDM and 1M byte of RAM, approximately $3300; version with two QPDMs and 2M bytes of RAM, approximately $5500.

Eltec Elektronik GmbH, Galileo-Galilei-Strasse 11, 6500 Mainz 42, West Germany. Phone (06131) 50630. TLX 04187273.

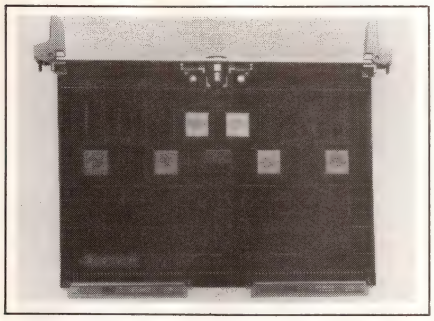
Circle No 666

American Eltec Inc, 569 S Marengo Ave, Pasadena, CA 91101. Phone (818) 449-1558.

Circle No 667

TRANSPUTER BOARD

The VMTM is a double-Eurocard VME Bus board that contains four T414 or T800 Inmos Transputers, each provided with 1M byte of local memory. Point-to-point routing of the 16 Transputer links, through which the Transputers communicate, is software configurable via an IMS-C004 link switch, allowing you to modify the topology of the Transputer array. The link switching also lets you access individual Transputers via the VME Bus. External link connections let you configure a Transputer array, using multiple



VMTM boards, or communicate with other Transputer systems.

Program development is supported by the Occam programming language and by C, Pascal, and Fortran-77 compilers. The board is suitable for use as an accelerator for VME Bus systems or as a multiuser Transputer development system. As a development system, each board can support four users. A software-development package, Megatool, is available to support the use of the board as a multiuser Transputer development system in OS-9 VME Bus systems and in Sun workstations operating under Unix. Populated with T414 Transputers, the VMTM board costs DM 13,800.

Parsytec GmbH, Juelicher Strasse 338, 5100 Aachen, West Germany. Phone (0241) 1822275.

Circle No 670

TRANSPUTER BOARD

Equipped with nine 32-bit T414 or T800 Transputers, each having 1M byte of RAM, the Fast9 add-in board provides IBM PC/ATs or compatible computers with 90 MIPS or 13M flops of processing power. The Transputers are organized as one master and eight slaves. Transputer links from the slaves are routed through a software-programmable IMS-C004 link switch, allowing you to configure the Transputer array in a range of topologies. In addition, you can route 16 Transputer links to adjacent Transputer boards to create larger Transputer arrays.

The master Transputer controls the link switching and supervises operation of the other eight Transputers. The software provided with the board includes support for the IBM PC host interface and control of the slave Transputers and programmable link switch. The board runs all the Inmos Transputer development software. Version with T414-20 Transputers, £9950; version with T800-20 Transputers, approximately £12,000.

Quintek Ltd, Southfield House, 2 Southfield Rd, Westbury-on-Trym, Bristol BS9 3BH, UK. Phone (0272) 628196. TLX 449683.

Circle No 676

I/O BOARDS

The VIOS and VIOP are intelligent, single-Eurocard VME Bus I/O boards providing serial and parallel I/O facilities, respectively. Each board has an onboard 68000 μP

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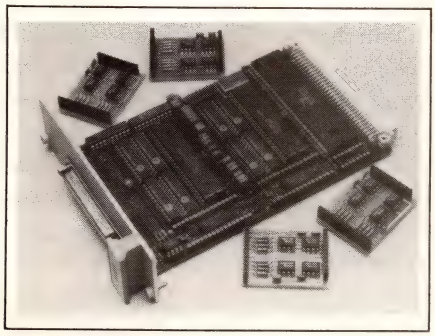
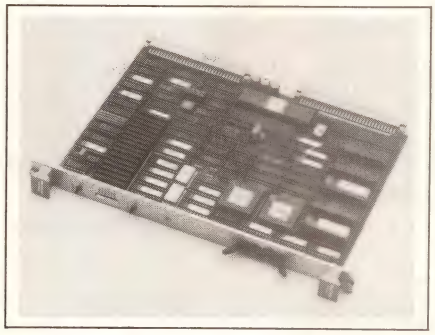
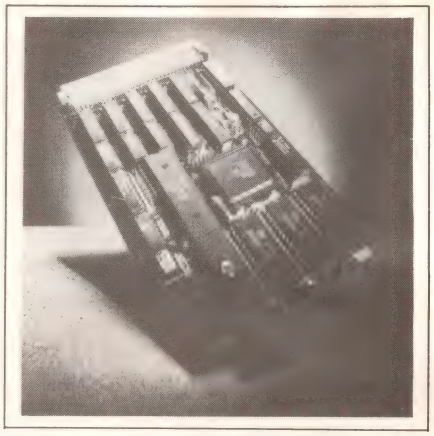
CIRCLE NO 30







provided with 64k bytes of local RAM (expandable to 256k bytes), and 64k bytes of dual-port RAM (expandable to 512k bytes for the VIOS and 256k bytes for the VIOP). The boards also have two 32-pin JEDEC-compatible memory sockets for as much as 256k bytes of EPROM.

The VIOS board provides you with four synchronous/asynchronous I/O channels controlled via 68562 communications controllers. You can configure these channels as RS-232C, RS-422, RS-485, 20-mA current loop, or fiber-optic interfaces by installing small piggyback boards.

The VIOP has two 68230 I/O/timer ICs that provide 32 individually programmable I/O lines and eight control lines. Piggyback options provide 16-bit parallel input or parallel output ports plus four control lines. The company can also provide an optically isolated version. VIOS, DM 1450; VIOP, DM 1300.

Pep Modular Computers GmbH, Am Klosterwald 4, 8950 Kaufbeuren, West Germany. Phone (08341) 81001. TLX 541233.

Circle No 671

Pep Modular Computers Inc, Carnegie Office Park, 600 N Bell Ave, Pittsburgh, PA 15106. Phone (412) 279-6661. TLX 6711521.

Circle No 672

BOARD COMPUTER

The CC-97 is suitable for use as an intelligent SCSI-bus controller or CPU card in VME Bus systems or as a stand-alone computer board. The double-Eurocard board has a 16-MHz 68000 or 10-MHz 68010 μP, and an 8-MHz 68450 DMA controller, both of which can access the 2M bytes of onboard dual-port RAM without wait states. It provides eight 28-pin memory sockets in which you can install as much as 256k bytes of EPROM and 128k bytes of static RAM. Battery backup facilities are provided for static RAM. A 512-byte EEPROM holds system-configuration parameters.

The board's SCSI-bus interface uses the WD33C93 SCSI-bus controller chip to support mass-storage devices, and the board also has communication controllers for two asynchronous serial channels, and two multiprotocol synchronous/asynchronous serial channels. A battery-backed real-time clock/calendar/alarm and three 16-bit timer/counters are also provided.

The card gains access to the VME Bus via an A24, D16 interface that supports multiprocessor environments with a VME Bus interrupt requester and handler and mailbox facilities. The CC-97 draws around 2.6A from the 5V supply and operates over 0 to 70°C. Approximately $3600.

Compcontrol bv, Stratumsedijk 31, 5600 AD Eindhoven, The Netherlands. Phone (040) 124955. TLX 51603.

Circle No 673

Compcontrol Inc, 15466 Los Gatos Blvd, Suite 109-365, Los Gatos, CA 95032. Phone (408) 356-3817. TWX 510-601-2895.

Circle No 674

CPU CARD

The SC280 is a single-Eurocard STE Bus CPU card based on a 10-MHz Z280 μP. The Z280 is code compatible with the Z80 μP and features an on-chip cache, pipeline architecture, and MMU, DMA, and serial-I/O facilities. The board has four JEDEC-compatible, 28-pin memory sockets. Three of these sockets can accommodate as much as 96k bytes of static RAM, which is sufficient for the board to run CP/M with only the addition of a suitable floppy-disk-drive controller board and disk drive. Two of the four sockets together accept as much as 128k bytes of EPROM. Additional onboard facilities include two RS-232C I/O channels, one 2-wire RS-485 I/O channel, and four counter/timers.

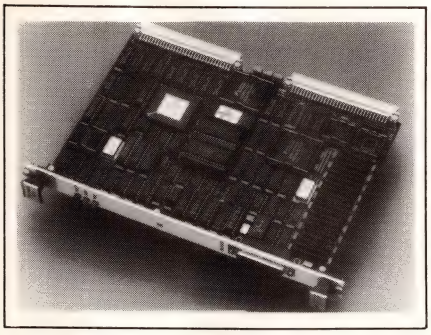
The board's STE Bus interface handles as many as six STE Bus interrupts and two DMA requests. Bus timeout, system clock, and reset functions are also provided, and the board can operate in multimaster STE Bus systems that incorporate a bus arbiter. The board's power-supply requirements are 1A at 5V and <30 mA at ±12V. £295.

Arcom Control Systems Ltd, Unit 8, Clifton Rd, Cambridge CB1 4WH, UK. Phone (0223) 411200. TLX 94016424.

Circle No 675

HOST ADAPTER

The PT-VME420 SCSI/VME Bus host adapter for the VME Bus provides onboard resources that are built around a 12.5- or 16.7-MHz 68020 CPU. The module has two DMA devices. The DMA interfaces

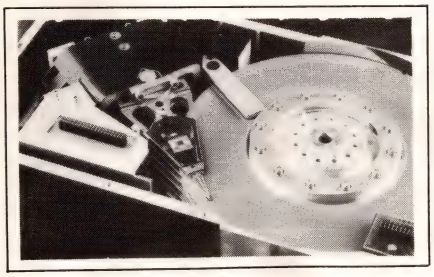


transfer data concurrently to or from a 512k-byte dual-access RAM (2M bytes optional). One DMA interface moves VME Bus data at sustained rates of more than 12.5M bytes/sec. The other DMA interface moves data to and from a SCSI bus at sustained rates of more than 4M bytes/sec with a burst rate of more than 5M bytes/sec.

The SCSI bus interface is based on the Western Digital WD33C92/93 VLSI chip. The firmware supports SCSI operation in conformance with ANSI X3T9.2 rev 17 and handles multithreaded and scatter-gather operations. In a target mode, two SCSI host adapters can be operated back to back, allowing intersystem communications via the SCSI bus. You can also use a resident diagnostic Trace function that allows a real-time display of SCSI-bus activity and host-to-host adapter commands. $2095.

Performance Technologies Inc, 435 W Commercial St, East Rochester, NY 14445. Phone (716) 586-6727. TWX 650-293-8297.

Circle No 641



8-IN. DISK DRIVE

The Sabre 1230 quarter-rack disk drive features a storage capacity of 1236M bytes. It has a transfer rate of 3.02M bytes/sec with an average seek time of 16 msec. The drive uses both thin-film media and thin-film heads. Interface options include SMD-O, SMD-E, SCSI, and IPI-2. The drive uses a 2,7 RLL recording code to achieve a high-density recording.

The unit includes eight disks, and it provides 15 surfaces and 1635 tracks/surface. A dedicated μP provides position control for the closed-loop servo system. The drive also includes built-in diagnostics and self-test features. $6470 (OEM qty). Production deliveries are expected during the second quarter of 1988.

Control Data Corp, Box 0, Minneapolis, MN 55440. Phone (612) 853-7388.

Circle No 642

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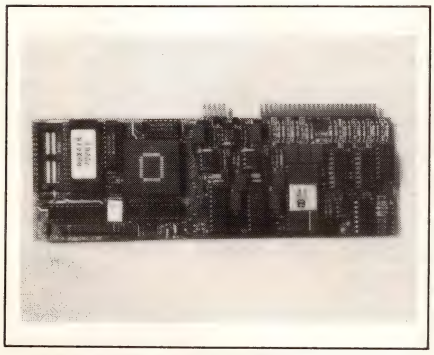


ANALOG I/O CARD

The RBX428 is an intelligent analog I/O card for the SBX Bus. The card has 16 single-ended or eight differential analog inputs and two analog outputs. A CMOS 8051 μP, having a 64k-byte EPROM and 32k bytes of RAM, provides the onboard intelligence. The card also incorporates a 128-byte FIFO buffer, which transfers data to and from the card. The analog input section includes an instrumentation amplifier with resistor-programmable gain, an S/H-amplifier circuit, and an A/D converter with 12-bit resolution.

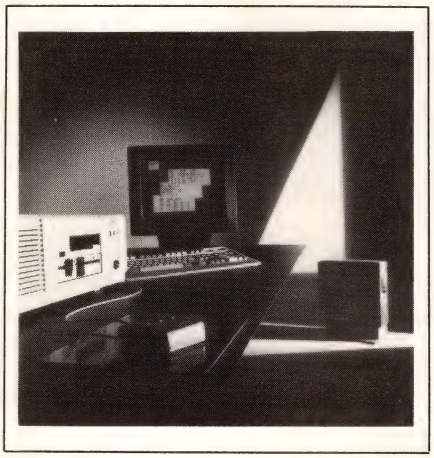
Input voltage ranges can be unipolar (50 mV to 10V) or bipolar (±25 mV to ±10V). The analog inputs are protected to ±32V. A space is provided for you to install lowpass filters to reduce input noise. The A/D converter has a throughput conversion rate of 33 kHz; an optional 59-kHz A/D throughput rate is available. The two analog outputs have 12-bit resolutions, and jumpers let you set one of six voltage ranges. $695.

Robotrol Corp, 16100 Caputo Dr, Morgan Hill, CA 95037. Phone (408) 778-0400.

Circle No 643

WORKSTATION

The RD²S 3000 is a fully integrated workstation. Running on Unix System V release 3.0, the system supports reasoning-based software called RelationalLisp, a Common Lisp database integrator. RelationalLisp lets you represent, reason about, and manipulate large-scale databases from within Common



Lisp. You can also connect the software to existing commercial databases. The system also provides full control of X-Windows from Common Lisp.

The system is based on a 16-MHz 80386 μP with a memory capacity of 4M to 16M bytes. The I/O bus is PC/AT compatible and has four slots available for expansion. An 80287 coprocessor is standard and an 80387 is optional. You can choose from three types of monitors with resolutions of 1280×1024 pixels: a 20-in. diagonal black and white, a 16-in. diagonal RGB color, and a 19-in. diagonal RGB color monitor. The system's mass storage includes a 1.2M-byte floppy-disk drive; a hard-disk drive with a capacity of 72M to 120M bytes; and a 60M-byte tape-cartridge drive. From $19,985.

MAD Intelligent Systems Inc, 2950 Zanker Rd, San Jose, CA 95134. Phone (408) 943-1711. TLX 171827.

Circle No 644

PROTOTYPING BOARD

The SP-Proto double-Eurocard VME Bus board provides you with a ready-made VME Bus interface, and a wrap-and-wire area in which you can prototype circuits. The module's VME Bus (Rev C) interface handles all VME Bus timing and control signals, address decoding, data-bus control, DTACK generation, and interrupt-request and interrupt-vector generation. All processed VME signals are available on two duplicated connectors.

The interface accepts three positive-edge-triggered onboard interrupts, routing them on a single VME Bus interrupt level with different interrupt vectors. You can program the interrupt level and the vectors used. You can also implement dual-port RAM on the board without having to add extensive arbitration logic. $613.

NV Spinnov SA, Pleinlaan 2, Building K6, 1050 Brussels, Belgium. Phone 02-641 2844. TLX 61051.

Circle No 645

DMA CONTROLLER

The NB-DMA-8-G multifunction interface board for the MacIntosh II computer functions as a DMA controller and as an interface between the PC Nubus and an IEEE-488 bus. The board's functions include eight DMA channels, eight counter/timer channels, and eight interrupt channels. The 32-bit DMA controller handles the Macintosh's full 4G-byte address space and can transfer data across the bus at 13M bytes/sec for 32-bit transfers. The board is one of a series of boards from the vendor that feature the National Instrumentation Real-Time Integration (RTSI) bus.

The RTSI bus transfers analog and digital information between plug-in boards over a 50-pin ribbon cable. The DMA controller board unit manages the RTSI bus by providing timing functions and interrupt support. The board and the RTSI bus operate with the company's LabView software. $1295.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. Phone (800) 531-4742; in TX, (800) 433-3488. TLX 756737.

Circle No 648

1-BOARD COMPUTER

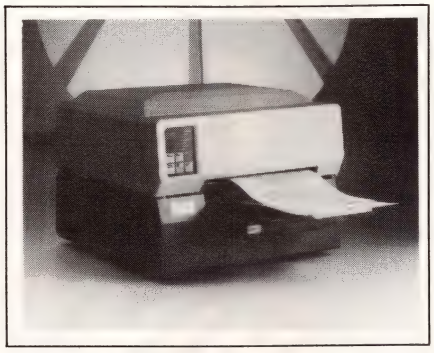
The CY4110 is a VME Bus single-board computer on a 9U×280-mm Eurocard. The board's large format

lets the manufacturer provide a number of features, including a 68020 CPU (in 12.5-, 16.67-, or 20-MHz versions), an optional 68881 floating-point coprocessor, an optional 68851 paged MMU, and 2M or 4M bytes of dual-ported dynamic RAM with parity. The board also contains four 28-pin JEDEC ROM/static-RAM sockets configured as a 32-bit memory, one 28-pin JEDEC ROM socket for the monitor/debugger, a 68440 2-channel DMA controller, and a floppy-disk-drive controller. It also has a SCSI interface, a parallel printer port, four RS-232C ports, a 24-bit counter/timer and real-time clock, and a VME Bus master/slave interface (A32, D32).

In parallel-processing systems, the board allows the 68020's local resources to be truly local, reserving the system bus for global communications and system resources. 12.5-MHz version with 2M bytes of dynamic RAM, $5700; 20-MHz version, $6100.

Cyclone Microsystems, 25 Science Park, New Haven, CT 06511. Phone (203) 786-5536.

Circle No 646



PRINTER

The CrystalPrint VIII is a nonimpact page printer that combines a printer-resident controller with a Casio liquid-crystal shutter (LCS) print device. Because the LCS technology requires fewer moving parts than laser technology, the manufacturer claims that it's more reliable. However, LCS technology provides the same resolution (300 dots/in.) that a laser printer does. The controller emulates Hewlett-Packard's LaserJet Plus printer, thus making the printer compatible with Microsoft's Windows and the Aldus PC Pagemaker. The printer puts out eight pages/minute.

Other features include three ROM-resident and cartridge-based type fonts from Bitstream; downloadable fonts, including H-P compatible fonts; 1.5M bytes of RAM for 300-dot/in. bit-mapped graphics on DIN A4, DIN B5, letter- and legal-size paper; and optional Epson, Diablo, HPGL, and IBM ProPrinter command and font emulations. $2495.

Data Technology Corp, 2551 Walsh Ave, Santa Clara, CA 95051. Phone (408) 727-8899. TLX 4745044.

Circle No 649

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Shapes and Dimensions

Stack type
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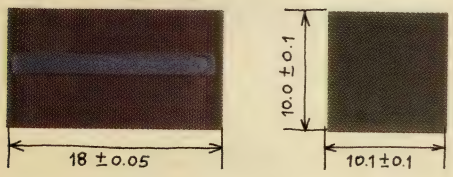
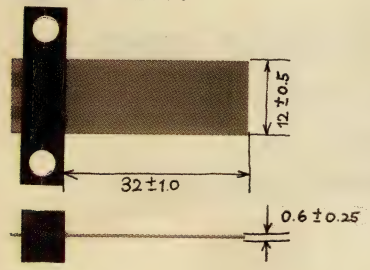


Bimorph type
NLB-40 × 12 × 1



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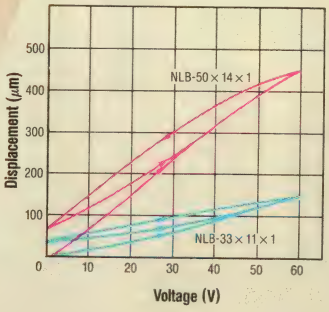
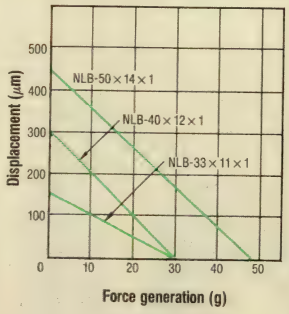
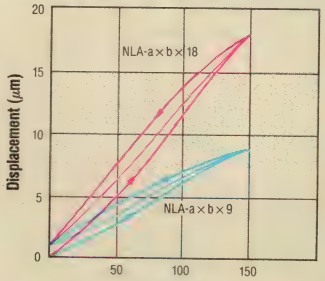
Voltage vs. Displacement



Force generation vs. Displacement (measured at 60V DC)

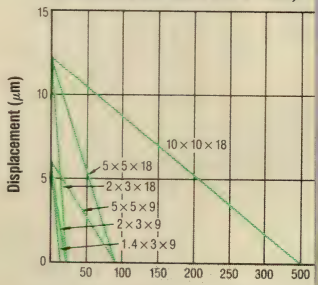


Voltage vs. Displacement



Displacement reduction ratio is 5% or less at 85°C.

Force generation vs. Displacement (measured at 100V DC)



Performance

	Dielectric displacement	Force generation
Stack type	(μm/100V) ±10%	(kg/100V) ±20%
NLA-1.4 × 3 × 9	6.5	14.0
NLA-2 × 3 × 9	6.5	21.0
NLA-2 × 3 × 18	15.0	21.0
NLA-5 × 5 × 9	6.5	87.0
NLA-5 × 5 × 18	15.0	87.0
NLA-10 × 10 × 18	15.0	350.0
Bimorph types	(μm/60V) ±20%	(g/60V) ±20%
NLB-33 × 11 × 1	150	30
NLB-40 × 12 × 1	300	30
NLB-50 × 14 × 1	450	48

Tokin

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CIRCLE NO 72

1987

Product Database Index

(May through October 1987)

Including products from EDN and EDN News

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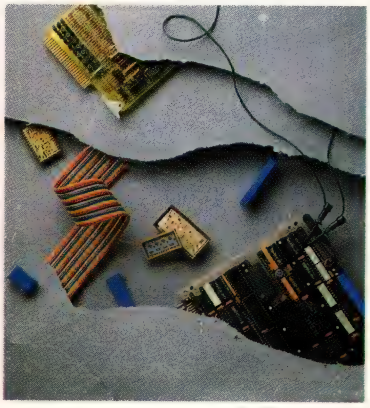

The database represents products that received editorial coverage in EDN and EDN News between May and October 1987. EDN's products include those featured in Product Updates, showcases, and individual short-product sections. The products from EDN News include those from the New Products and Product Features sections.

You'll find products in eight main groups:

Computer-Aided Engineering Software
Computers and Peripherals
Components
Hardware and Interconnect
ICs and Semiconductors
Test and Measurement Instruments
Power Sources

For more information about the products in the Index, use the addresses in EDN and EDN News to contact the manufacturers directly.

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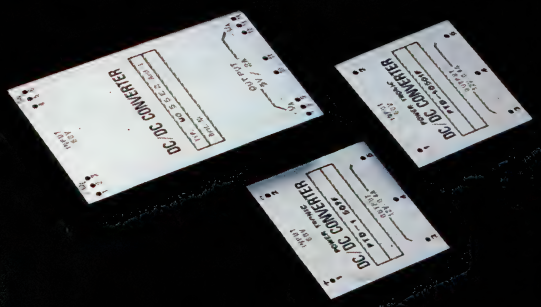

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PTA-4135 CF
PTA-4195 CF

PTA-4200 DA

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LR 65702

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Publication describes control software

This 6-pg brochure examines On-Spec Control Software, a software package for control of high-speed data-acquisition hardware and industrial computers. The 4-color publication details the software's features, options, and applications; lists supported hardware; and describes the vendor's user-support services.

Heuristics Inc, 9723A Folsom Blvd, Suite 231, Sacramento, CA 95827.

Circle No 437

Guide to software and services

The Directory of Micro Engineering Software/Services provides detailed information about engineering software and associated services. The book, divided into 27 sections, contains more than 700 engineering packages and furnishes more than 250 company descriptions. The packages are grouped into sections by their engineering function, such as civil engineering, CAD, mechanical engineering, or structural/stress analysis. The book provides you with system requirements, pricing, and maintenance/support information. The company descriptions include market emphasis, types of services provided, sales volume, geographical area serviced, and principal contacts. The directory also includes a product index, which lists packages in alphabetical order; a vendor index that helps you determine which packages and services a vendor offers; and a service index that cross-references the service vendors according to the type of service offered and the market area serviced. $239.

Decision Graphics Inc, 555 Sparkman Dr, Suite 652, Huntsville, AL 35816.

INQUIRE DIRECT

Software users' journal

Reference(Clipper): The Independent Guide to Clipper Expertise is designed to aid users of Clipper software. It provides programming tips, user-defined functions, database-management techniques, utility programs, and reviews and articles that deal with Clipper applications. Regular columns include features written by Clipper experts; reviews of Clipper-related products; Utility of the Month user-defined functions of the month; a column on networking solutions; an Expert's Log: Advanced Tutorial; Beginning User's Log; Advanced User's Log; and Procedure of the Month. The journal is published monthly. Annual subscription, $89; 2-year subscription, $160.

Pinnacle Publishing Inc, Box 1693, Tacoma, WA 98401.

INQUIRE DIRECT

Publication reports on software

The quarterly newsletter, *Software Technology Report*, details information about current software design and implementation, testing topics, and product reviews. Future reports will address such topics as how to design and implement machine-independent software modules and how to select programming languages. Annual subscription, $29. To obtain a free sample issue, send a self-addressed stamped envelope.

Software Technology Report, Microcomputer Applications, Box E, Suisun, CA 94585.

INQUIRE DIRECT

Document explains software system

This 4-pg, 4-color brochure presents an overview of the company's Opera software system, a project-management risk-analysis program for the IBM PC, PC/XT, PC/AT, and compatibles. The publication sums up the package features, lists the hardware/software requirements, and contains drawings of sample screens.

Welcom Software Technology, 1325 S Diary Ashford, Suite 125, Houston, TX 77077.

Circle No 438

Directory lists more than 1700 computer programs

You can now obtain the 1987 edition of the *Directory of Computer Software* from the National Technical Information Service of the US Department of Commerce. Listing more than 1700 federal common-use programs that have been tested and proven for mainframes and μCs, the directory is keyed two ways: by subject categories, which list brief program abstracts; and in indexes by agency, accession number, and subject. These indexes contain all computer programs in the directory; additional hardware and language indexes contain entries for a limited number of programs. The directory includes 100 new programs from the National Energy Software Center. $48.

US Department of Commerce, National Technical Information Service, 5285 Port Royal Rd, Springfield, VA 22161.

INQUIRE DIRECT

Data converters and voltage references presented

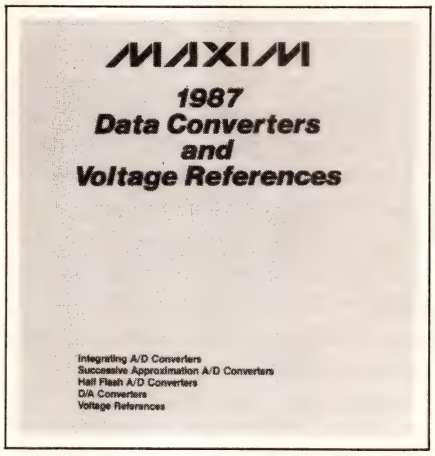
The 320-pg data book *1987 Data Converters and Voltage References* details information about 27 ADCs (including 16 new devices) and 11 voltage references. It provides a complete product list, converter selector guides, package information, and a listing of US sales representatives and distributors.

Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086.

Circle No 610

Guide helps you select IC products

The 64-pg *Product Selector Guide and Price List* features new products, a product application guide, and a full product-line selector guide. Also included is information about custom products; quality assurance, reliability, and HR programs; die and wafer sales; and surface-mount products. An industry cross-reference and price list, as well as listings of the vendor's sales representatives, franchised distributors, chip distributors in the US, and international sales representatives, complete the catalog.



Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086.

Circle No 611

Handbook summarizes analog applications

The *1987 Analog Data Acquisition Applications Seminar* handbook treats a wide range of topics, including CMOS data converters, video amplifiers and multiplexers, low-power dc/dc converters, switched-capacitor filters, surface-mount packages, op amps, and μP support circuits. Figures, schematics, tables, and illustrations complete the publication.

Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086.

Circle No 614

Disk speeds selection of power transistors

Specs in Secs is a catalog on a disk that contains information about more than 1600 bipolar power transistors and power MOSFETs and features more than 3500 cross-refer-

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Motorola Semiconductor Products, Literature Distribution Center, Box 20924, Phoenix, AZ 85063.

INQUIRE DIRECT

Report discusses surface-mount devices

The *Surface Mount Devices Reliability Report* (RR-2) covers the step-by-step development of reliable surface-mount devices. It highlights the vendor's molding compound, lead frame, and manufacturing flow, which, the vendor claims, provide greater reliability than do standard surface-mount-device manufacturing materials and flows. The publication also describes the vendor's design and testing methodology and quality-assurance program.

Maxim Integrated Circuits, 510 N Pastoria Ave, Sunnyvale, CA 94086.

Circle No 616

Reference for bipolar power transistors

The fifth edition of the *Bipolar Power Transistor Selector Guide and Cross Reference* (SG48) contains device-selection tables that include European-manufactured devices, as well as sections on Switchmode, Darlington, and low-voltage power-switching transistors and military-qualified devices. The publication features revisions to the cross-reference that increase its accuracy, and suggests alternatives for discontinued items; it lists more than 1100 standard off-the-shelf power transistors and several thousand special types of bipolar power transistors.

Motorola Semiconductor, Literature Distribution Center, Box 20924, Phoenix, AZ 85063.

Circle No 612

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Brooktree Corporation, 9950 Barnes Canyon Road, San Diego, California 92121. 1-800-VIDEO IC or 1-800-422-9040, in California.

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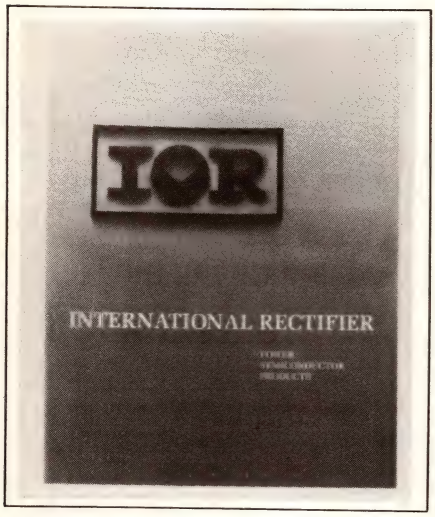
CIRCLE NO 35



Catalog of power semiconductors

The 144-pg *Power Semiconductor Catalog* covers the company's range of products. It provides tables with key specifications for each product type, accompanied by drawings of and dimensions for each package. The products covered include HexFET power MOSFETs; Schottky rectifiers; ultrafast-recovery diodes; standard- and fast-recovery rectifiers; phase-control, inverter-type, and gate-turn-off thyristors; power modules; military/government and custom products; and custom/standard assemblies, such as heat sinks and mounting hardware. Other sections are devoted to available literature, product cross-references, a JEDEC/alphanumeric index, and descriptions of quality/reliability programs.

International Rectifier, 233 Kansas St, El Segundo, CA 90245.

Circle No 430

Power sources summarized

The expanded *Sola Products Catalog* now offers mail-in priority service cards that allow you to receive product updates, quotations on part numbers, or assistance from engineers. The 68-pg publication also presents the theory, design, and operation of the vendor's voltage-regulation and line-conditioning products. Divided into four sections, the book covers power conditioning, power-line monitors, uninterruptible power supplies (UPS), standby power sources (SPS), and power supplies. The new products it features are a 3-kVA UPS; 300- and 1200-VA SPSs; and a 50W single-output switching power supply.

Sola, 1717 Busse Rd, Elk Grove Village, IL 60007.

Circle No 341

Local and remote control of high voltage

Programmable High Voltage is an 18-pg, 4-color brochure that details programmable multiple-channel high-voltage power-supply systems. Its two main sections contain product summaries of the medium- and highest-density systems; these summaries include functional descriptions, features, specifications, and ordering information, as well as a number of illustrations.

LeCroy, 700 S Main St, Spring Valley, NY 10977.

Circle No 342

Packet contains facts about EMS products

The EMSPAK/D package combines available literature on the EMS (Energy Management Series) power-module products. Data sheets are included for products with current-handling capabilities ranging from 50 to 300A and 1000 to 1200V. Also included in the package is the EMS Selector Guide (SG114), along with data sheets for the 22 devices in the series.

Motorola Inc, Literature Distribution Center, Box 20924, Phoenix, AZ 85063.

Circle No 433

Brochure aids in choosing a UPS

The pamphlet *The Step-by-Step Guide to Specifying the Right UPS* presents an overall view of a UPS (uninterruptible power supply) to help you in selecting the UPS that best suits your needs. It provides a table with which you can determine your load profile, as well as two forms on which you can specify your single-phase and 3-phase UPS requirements. It also defines generic specifications and features three single-line UPS diagrams, depicting power supplies of 1 to 3 kVA, 5 to 10 kVA, and 15 to 50 kVA, respectively.

General Power Systems, Box 65008, Anaheim, CA 92805.

Circle No 434

Catalog details power supplies

This publication provides details and specifications for a range of power supplies and accessories. It covers 3, 5, and 15W encapsulated dc/dc converters; 40W single- and triple-output Eurocard dc/dc converters; 100W Euromodule dc/dc converters; 1 and 5W encapsulated linear power supplies; and Eurocard-footprint linear and switchmode power supplies.

A F Bulgin & Co plc, Power Conversion Div, Park Lane, Broxbourne, Hertfordshire EN10 7NQ, UK.

Circle No 436

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LITERATURE: HARDWARE & INTERCONNECT DEVICES

Coaxial products catalog

Catalog #587 is a 29-pg listing that features a full line of coaxial adapters, connectors, attenuators, terminations, and cable assemblies. The newly featured line of coaxial attenuators includes BNC, "N," SMA, and TNC. Both flexible and semirigid cable assemblies are available. The publication includes technical specifications and pricing for more than 1000 items.

Pasternack Enterprises, Box 16759, Irvine, CA 92713.

Circle No 420

EMC guide

The *Guide to Interference Control, Using Beryllium Copper* addresses a variety of EMC (electromagnetic compatibility) test-and-measurement and design concerns. The publication treats such topics as theoretical design requirements and the selection of specific shielding materials. It features charts, tables, graphs, and dimensional drawings.

Instrument Specialties Co, Delaware Water Gap, PA 18327.

Circle No 421

App note on fiber-optic LANs

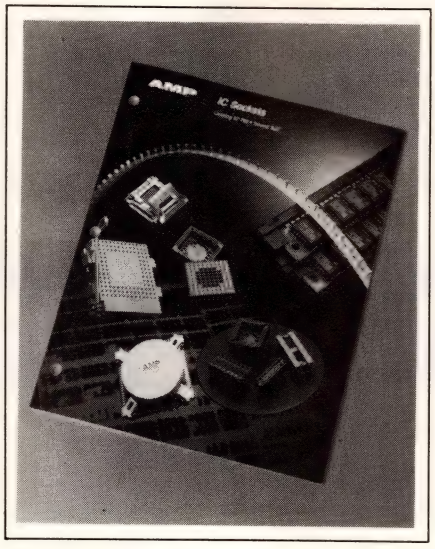
The 4-pg application note, *Testing Fiber Optic LANs*, covers the testing requirements of most of these devices, including Ethernet and token-ring LANs. The topics examined include testing fiber-optic cables, troubleshooting systems, and margin testing.

Fotec Inc, Box 246, Boston, MA 02129.

Circle No 423

Catalog focuses on IC sockets

Catalog 87-798 lists IC sockets that remove the risk of soldering ICs directly onto pc boards. The 130-pg book divides IC sockets into two categories—production sockets and test and burn-in sockets. It provides



photographs, drawings, and schematics, as well as detailed explanations of product features, performance characteristics, and materials. The publication's semiconductor-to-socket cross-reference chart matches common devices with complementing square and DIP sockets; its listings appear by manufacturer, part number, and description. Another special feature is a section on pin-grid-array patterns.

AMP Inc, Box 3608, Harrisburg, PA 17105.

Circle No 424

Catalog details jumpers

This 16-pg 1987 product-information catalog covers preformed jumper wires and bare-wire jumpers on tape and reel. Other products listed are precut hookup wires, kynar wires for wire wrapping, and cut tubing. A small packet of product samples is attached inside the front cover.

Squires Electronics Inc, 503 N 13th Ave, Cornelius, OR 97113.

Circle No 427

Data sheet for surface-mount repair

A 2-pg data sheet describes the vendor's SRM-100 surface-mount rework and repair system. The publication details how the system works and how it utilizes the proprietary programmable matrix heater. It also highlights the system's features and benefits, which include eliminating the need for expensive tooling to handle different surface-mount-device configurations. The data sheet's reverse side lists general, control-system, vision-system, utility, and physical specifications of the product.

SRTechnologies Inc, Pond Lane, Concord, MA 01742.

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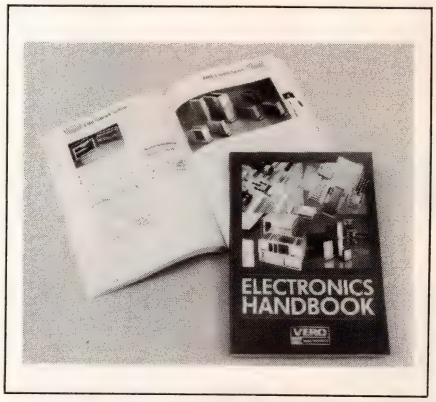

Handbook describes range of hardware products

The second edition of the *Electronics Handbook* describes the company's complete range of hardware products and power supplies. In addition to established product lines, new products described in the handbook include encapsulated dc/dc converters, open-frame and cased power supplies, new 19-in. and ABS plastic instrument cases, and IDC and environmentally sealed connectors. One section, devoted to μP system-hardware-support products, includes hardware components for the VME, Multibus-I and -II, and Futurebus bus standards. The last section of the book outlines the company's manufacturing service facilities for wiring and assembly operations.

Bicc-Vero Electronics Ltd, Flanders Rd, Hedge End, Southampton SO3 3LG, UK.

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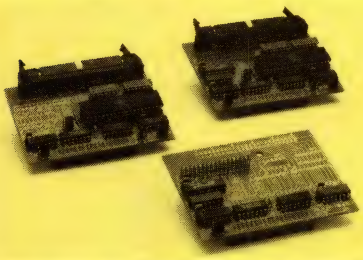

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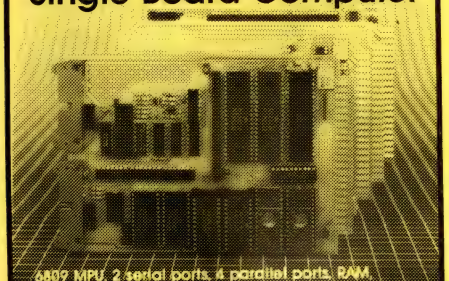

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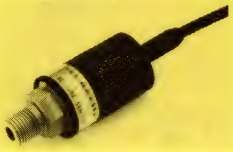

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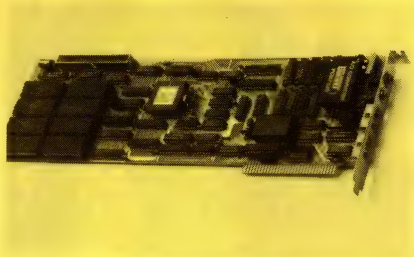

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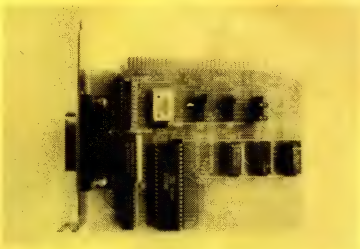

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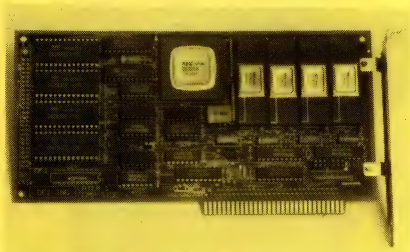

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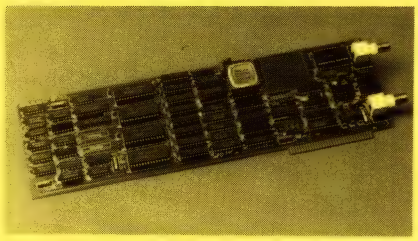

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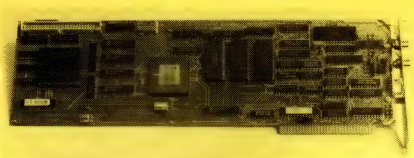

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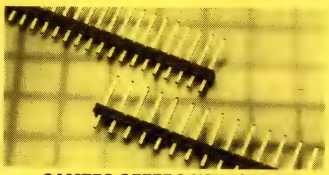

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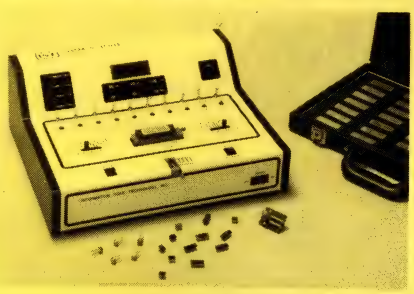

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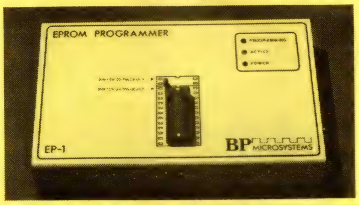

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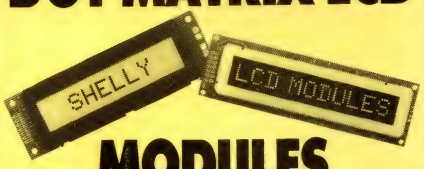

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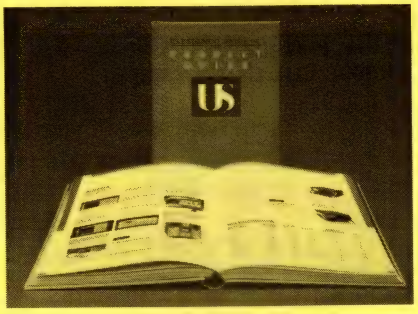

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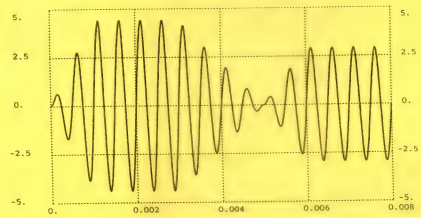

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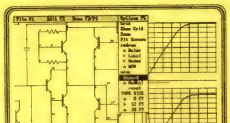

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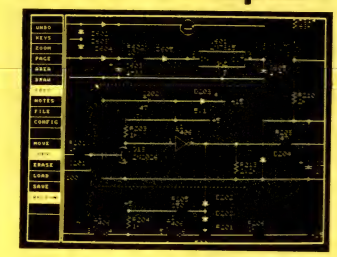

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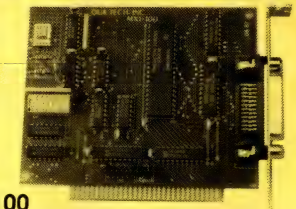

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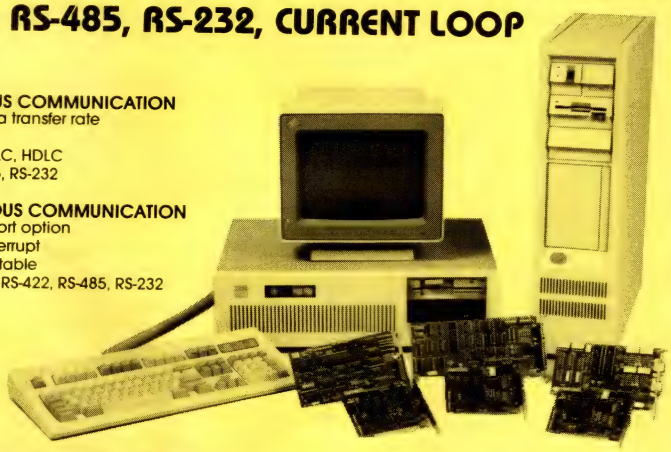

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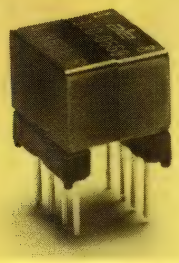

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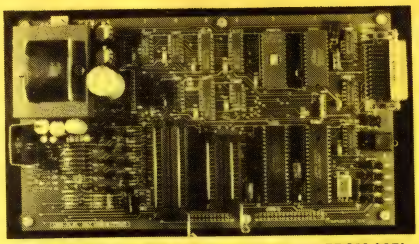

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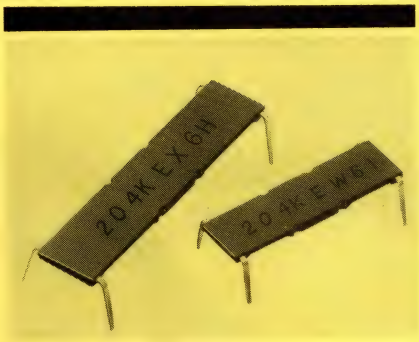

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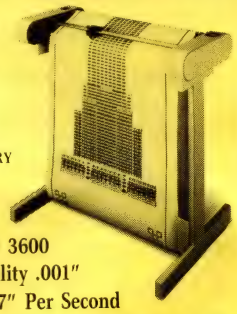

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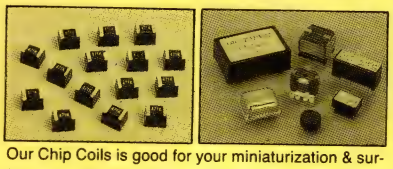

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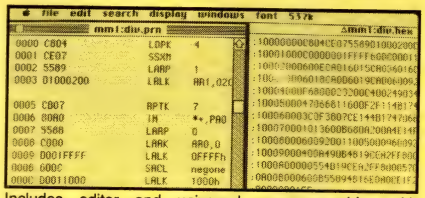

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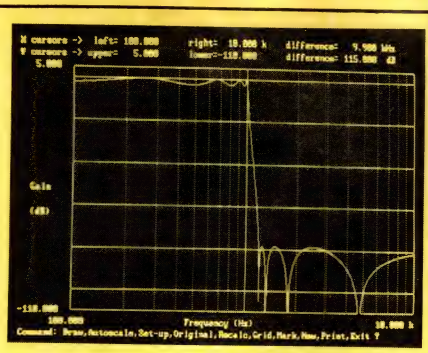

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How to work with a PATENT attorney

Richard Simonelli, *Ziji Technical Services*

If you plan to hire a patent attorney and assign him full responsibility for filing your application and tending to all the details, think again. Technically complex inventions require inventors to take an active role in the application process. Understanding the roles of the patent specialists with whom you'll work, as well as your own responsibilities, will increase your chances of being awarded a patent.

Many inventors seeking a patent hire a patent agent or a patent attorney. A patent agent can legally prepare a patent application and file it with the US Patent and Trademark Office (PTO) in Alexandria, VA. Patent agents, however, are not permitted to practice law. They can't legally represent you in court cases related to your patent application or to patents that you hold; however, a number of law offices and corporations employ both agents and attorneys. (For simplicity's sake, in this article references to patent attorneys also apply to patent agents.)

A patent attorney is a member of the Patent Bar and is permitted to practice before the PTO. Patent attorneys must have a technical background. They're required to have taken some science or engineering courses, and many hold college degrees in the sciences. Some worked as scientists or engineers before embarking on legal careers.

You must submit a well-prepared application because, if the PTO rejects it or objects to it, your amendments can't introduce new matter.

Although patent attorneys are often conversant in the physical sciences, you shouldn't expect to convey the details of your invention to a patent attorney with any less effort than you would expend briefing a colleague from a related but different field. As one patent attorney recently remarked, "If I understand it at a glance, it may not be worth patenting."

Your main contact at the PTO is the patent examiner assigned to your application. The PTO employs 1400 patent examiners, one of whom it assigns to review each patent application. The patent examiner assigned to your case has a technical background and some expertise in the field of your invention. When the PTO stipulates that "a person skilled in the art" must be able to practice an invention from its description in the patent application, they have the patent examiner in mind.

Often inventors are unavailable or too busy to provide the detailed technical information that the patent agent or attorney requires in the application-writing process. In such a case, it's advisable to retain a liaison person to work with the agent or attorney. The liaison person retained must be able to understand the invention and translate any technical information for the attorney, just as the inventor would.

Do your homework

Your work with any of these individuals, though, will proceed much more smoothly if you've already met certain conditions requisite to the issuance of most patents. Two items of importance in a patent application are the availability of dated and witnessed documentation recording the invention's technical progress, and timeliness in filing the patent application—two conditions that you are largely responsible for fulfilling.

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working on a project that might result in a patent to document the project's progress in a laboratory notebook. Notebooks for this purpose should contain bound and consecutively numbered pages. Periodically, an inventor should sign and date the notebook. In addition, at least one other technical person should sign and date the notebook, indicating that he or she has witnessed and understood the work.

If you didn't keep a notebook to chart your idea's progress, another form of documentation that establishes an invention's earliest date of record is a patent disclosure. In a patent disclosure, the inventor describes the invention's main ideas and theories. The PTO permits inventors to register patent disclosures themselves without the assistance of an attorney; the notebook, however, is the preferred method of documentation.

Dates recorded in the notebook or patent disclosure, as well as the date on which the invention was first built and tested, are useful evidence in the event of patent litigation. In case of conflict, the date on which the inventor filed the application becomes another important piece of evidence.

No matter how ready a market you see for an invention, be careful not to publish, make public, or offer to sell your invention more than one year prior to the date on which you file the application. Under the law, such actions constitute disclosure, and an inventor who discloses an idea too early is forever barred from obtaining a patent on it. Even an *offer* of sale may start the one-year clock. The rules for foreign patents are stricter: You are barred from obtaining a patent in most foreign countries if your invention was published anywhere or utilized within that country prior to the filing date.

Starting the application

The formal patent-application process begins when you contact an agent or attorney. One of the first things you should do is give your attorney a clear explanation of the need for your invention. Explain either in written or verbal form why the invention fills an as yet unmet need. Describe any related devices in your field and explain why your invention is different. Wax enthusiastic about your device relative to its particular market or technical

A format for patents

The **cover page** contains the title, abstract, and all legal and identifying data for the patent, as well as a reduced drawing of the invention. The PTO prepares the cover page from the specifications, drawings, and formal documents contained in the application and requires no direct assistance from the inventor.

The **abstract** of a patent briefly summarizes the patent disclosure and conveys key subject matter in a condensed format. A quick reading of the abstract is often useful when you are scanning a collection of patents in a prior-art search. A patent attorney typically prepares the abstract with no direct assistance from the inventor.

The **drawings** of the invention appear next. The inventor contributes the basic drawings, and the attorney places them in the proper format.

The **field of invention** constitutes a brief introduction to the body of a patent, indicating the kind of device that will be described. The patent attorney prepares this section. It appears after the cover sheet and the drawings.

The **background of the invention** appears next. It discusses the need for the invention and explains why specific examples of prior art do not accomplish what the invention does. The attorney prepares this explanation based on the discovered prior art and on information from the inventor.

The **summary of the invention** is another short statement. It describes the actual invention, introducing the more detailed explanations that follow.

The **brief description of the drawings** serves as the source of short captions for each figure in the application. The patent attorney prepares this portion of the application.

The **detailed description of the invention** is the technical meat of the application. It describes the invention in conjunction with the drawings in a manner that permits "one skilled in the art" to implement the invention. The inventor contributes to this portion. Good communication between an inventor and a patent attorney leads to a much stronger description.

The final part of the patent is the **claims** section. The claims define the portions of the invention for which legal protection is afforded. The claims establish the parameters of legal protection, and they are written by the attorney.

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niche, providing enough detail and content for the attorney to write a good background section for the application (see **box**, "A format for patents").

At this point, you should elect to have your attorney conduct a "prior art" search. Prior art refers to published material or working devices that publicly describe or that employ the principles of an invention. Issued patents, both foreign and American, are considered prior art. You may be unpleasantly surprised if a patent has already been issued for your idea or encouraged if your idea proves to be new. If you decide to pursue the patent, your application will probably cite the results of the prior-art search.

Inventors are legally obligated to bring to the PTO's attention all prior art of which they are aware. Bringing material prior art to the attention of your patent attorney is one of the first ways that you can assist the attorney in obtaining a valid patent. Even if some discovered prior art seems to hurt your chances for a patent award, be sure to inform your attorney of the discovery. Your attorney has the necessary legal know-how to best evaluate the significance of such discoveries.

Develop an accurate block diagram or a functional flow chart for the patent application. Keep the patent attorney and examiner in mind as you prepare these materials. Make sure that you represent each stimulus and response of your system and that you identify all electronic, mechanical, and software components. Be sure to include every important technical feature.

There are two important reasons for producing detailed, thorough drawings. The first reason is directly related to the application process: Should the PTO reject or object to your application, any amendments you make to it in response can't introduce new matter. So if the application contains at least one reference to each occurrence of important technical subject matter, your attorney will have legitimate material to cite or clarify in the amendment process. The second reason for making sure your drawings are complete is geared to the future: Work performed now will ultimately assist you in the commercial documentation for your idea once you've received a patent.

In some instances, software forms an integral part of a patent application. Anything you can do to explain how your software works to people who are not programmers or software engineers will help you in the long run. Although the preferred tools in software engineering are data-flow diagrams, structure charts, and menu trees, the PTO is much more comfortable with the venerable flow chart. Patent examiners are skilled in their assigned areas of technology, but their skills usually don't match those of practicing engineers.

Meet with your attorney as often as necessary to clarify technical points. Make good use of whiteboards or blackboards, just as you would in any R&D situation. But no matter how many "chalk talks" and discussions take place, it's a good

Why the patent examiner most often rejects a patent

Obviousness or anticipation: A patent rejected for its obviousness is one in which there are no new and unexpected results. The examiner states that although the invention is not identical to prior art, it would be an obvious extension of cited prior art to arrive at the present invention.

The examiner cites anticipation when he contends that, in one or more previous patents, your invention is essentially described or anticipated.

Failure to provide an enabling disclosure: The examiner states that the application provides insufficient technical detail to practice the invention. The attorney and inventor must amend the technical description to provide more technical detail, without inserting any new matter.

Improper legal format, or informalities in the drawings: In this case, the examiner states that the format of the application violates one of the PTO's many rules pertaining to legal form. He may also contend that one or more of the drawings violate the format requirements. In this case, the patent attorney must amend the application or drawings to clear up the cited problems. The inventor rarely needs to assist in this process.

More than one invention exists within the application: The examiner states that there is, in effect, more than one invention being claimed. You and your attorney are requested to elect a single invention to pursue. You may file a divisional application to cover the other invention(s) in the application. You still retain the original filing date if you file a divisional application.

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idea to supply your attorney with written documents that outline your idea's key points. Written documents left with your attorney provide an additional opportunity to establish a date for your invention.

Be sure that you divulge to your attorney the best techniques for implementing your invention. Patent law requires that an application divulge the "best mode" of invention known at the time of the filing. Don't hold back information in a misguided attempt to retain a different approach for other purposes.

If you have effectively communicated the technical information to your patent attorney, a first draft of the application should soon be ready for your review. Most of the draft application will be familiar because of your technical input. What you will see for the first time is the claims section of the patent, which defines the scope of legal protection that your invention will receive should it be awarded a patent.

Understand what patents protect

There are two kinds of claims, independent and dependent. Independent claims are broad in scope and define the technical art unique to your patent in a manner that results in expansive legal protection. Dependent claims limit the definition of the independent claims and are narrow in scope.

Examine the claims carefully. Do you understand which claims are independent and which claims are dependent? Has the attorney claimed everything you think should be claimed? Do you understand the terminology of the claims? Remember that art that is mentioned in the descriptive portions of the patent, but not claimed, is legally unprotected. Is it clear to you which technical features your patent will protect? Don't be shy. Question your attorney as extensively as you feel necessary.

Within six to 15 months, your attorney's office will receive the first formal communication from the PTO regarding your patent application. These formal communications are called office actions. The first action is often the examiner's rejection or objection. If the PTO rejects your application, you have a limited period, usually no more than six months and often less, within which to make a timely response.

The PTO rejects or objects to a patent on any of several grounds (see **box**, "Why the patent examiner most often rejects a patent"). Your attorney will respond to the office actions, most of which are nontechnical in nature, by amending the application and making counter arguments. Even if your technical assistance isn't needed, make certain you're kept up to date on all actions and responses.

Often the examiner turns up prior art not cited in the application and rejects the application on the basis of this prior art. Have your attorney provide you with copies of the examiner's citations. Read them carefully. Identify any technical differences, and relay your findings to your attorney. Later, meet with your attorney and review counter arguments. If the art is similar to your invention, one or more brainstorming sessions between you and your attorney may well identify essential differences between your invention and the prior art. Your attorney will then place the technical arguments in the appropriate legal formats, modify the claims if necessary, and submit an amendment to the PTO.

Sometimes it's useful to meet with the examiner and discuss the problems. The presence of the inventor or a liaison at such a meeting can clarify technical points. Some inventors take this opportunity to demonstrate their inventions. Examiners often enjoy seeing a physical embodiment of the invention or a device that incorporates the invention.

If you participate in such an interview, keep your role upbeat, enthusiastic, and technical. The interview is a human interlude in a process that so far has been technical and routine. Address the aspects of your invention that the examiner objects to. A little human contact, properly applied, can often break a logjam and result in the acceptance of your application.

Once the PTO has granted a patent and the applicant paid the issuance fee, the patent issues in about three months. That's the time for champagne, handshakes, and congratulations—a little celebrating before you get back to work on the next invention.

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Author's biography

Richard Simonelli is an independent consultant based in Boulder, CO. He received a BSEE from the Polytechnic Institute of New York and an MSEE from Cornell University. He has 22 years of engineering experience in analog and digital design.

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Feb. 18	Jan. 28	Materials & Hardware, CAE, Power Sources	
Mar. 3	Feb. 11	Communications, CAE, High-Speed Logic	Closing: Mar. 3 Mailing: Mar. 24
Mar. 17	Feb. 25	Graphics, Filters, Software/CAE	
Mar. 31	Mar. 10	Power Semiconductors, Memory/Graphics, Fiber Optics	
Apr. 14	Mar. 23	Communication Technology Special Issue, Communication Systems	Closing: Mar. 31 Mailing: Apr. 21
Apr. 28	Apr. 7	Software, Industrial Computers, Interface ICs	
May 12	Apr. 21	Analog Technology Special Issue, Analog Converters	Closing: Apr. 28 Mailing: May 19
May 26	May 5	CAE, Software, Sensors/Transducers	
June 9	May 19	CAE, Analog ICs, Test & Measurement	Closing: May 29 Mailing: June 16
June 23	June 2	Data Communications, DSP, Components	
July 7	June 14	Product Showcase—Vol. I, Power Sources, Software	Closing: June 23 Mailing: July 14
July 21	June 30	Product Showcase—Vol. II, CAE, Test & Measurement	
Aug. 4	July 14	Sensors & Transducers, Analog ICs, Graphics	Closing: July 21 Mailing: Aug. 11
Aug. 18	July 28	Military Electronics Special Issue, Displays, Military ICs	
Sept. 1	Aug. 11	Instruments, Op Amps, Computers & Peripherals	Closing: Sept. 1 Mailing: Sept. 22
Sept. 15	Aug. 25	Data Acquisition, Data Communications, Digital ICs	
Sept. 29	Sept. 8	DSP, Graphics, Optoelectronics	
Oct. 13	Sept. 22	Test & Measurement Special Issue, Instruments, Computers & Peripherals	Closing: Sept. 29 Mailing: Oct. 20
Oct. 27	Oct. 6	CAE, Computers & Peripherals, Integrated Circuits, Wescon '88 Show Preview	
Nov. 10	Oct. 20	Programmable Logic Devices, Integrated Circuits, Test & Measurements, Wescon '88 Show Issue	Closing: Oct. 27 Mailing: Nov. 17
Nov. 24	Nov. 3	Microprocessor Technology Directory Graphics, CAE	
Dec. 8	Nov. 16	Product Showcase—Vol. I, Power Sources, Software	Closing: Nov. 21 Mailing: Dec. 15
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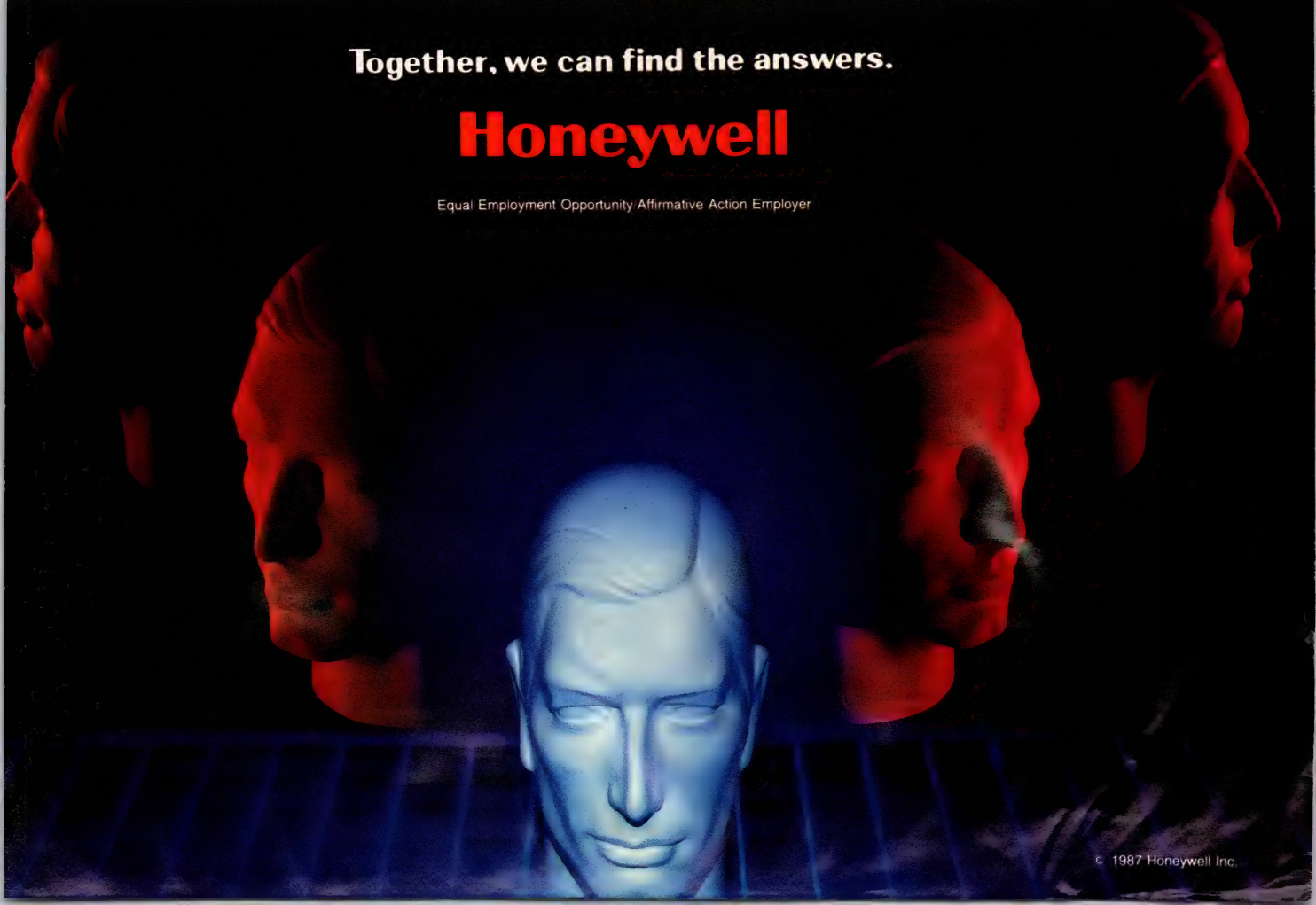

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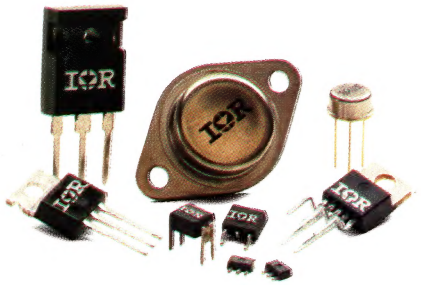

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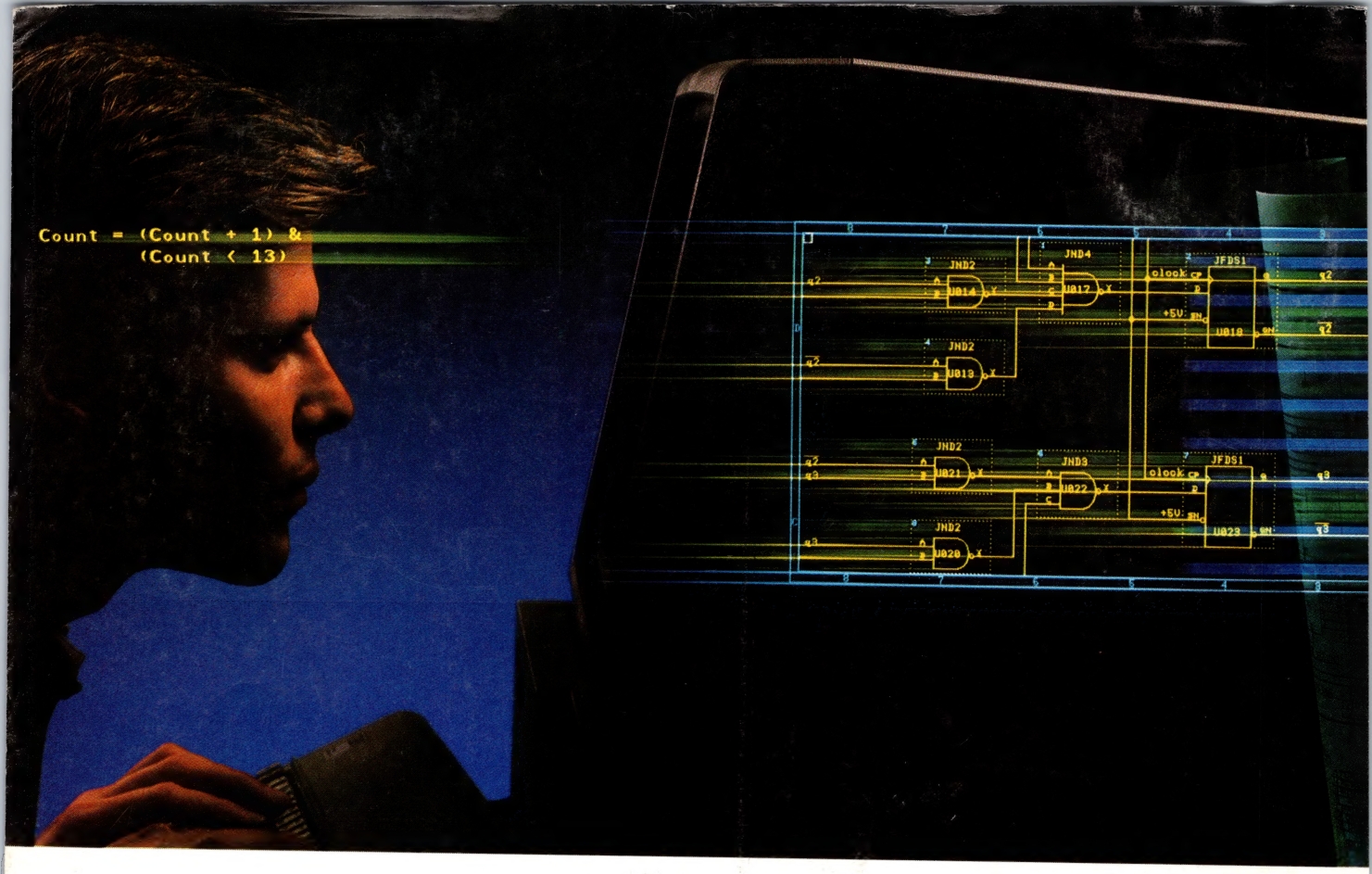

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